



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : A61F 2/06	A1	(11) International Publication Number: WO 99/18888 (43) International Publication Date: 22 April 1999 (22.04.99)
<p>(21) International Application Number: PCT/US98/21106</p> <p>(22) International Filing Date: 6 October 1998 (06.10.98)</p> <p>(30) Priority Data: 08/947,620 9 October 1997 (09.10.97) US</p> <p>(71) Applicant: SCIMED LIFE SYSTEMS, INC. [US/US]; One Scimed Place, Maple Grove, MN 55311 (US).</p> <p>(72) Inventors: LEY, Timothy, J.; 668 Highway 96 West, Shoreview, MN 55126 (US). KVEEN, Graig, L.; 14125 74th Place North, Maple Grove, MN 55311 (US). EHR, Timothy, G., J.; 19017 Zane Street N.W., Elk River, MN 55330 (US). BROWN, Brian, J.; 178 Jandel Avenue N.E., Hanover, MN 55341 (US). FRIESEN, David, L.; 8149 Sierra Parkway, Brooklyn Park, MN 55444 (US).</p> <p>(74) Agents: ARRETT, Oliver, F. et al.; 6109 Blue Circle Drive, Minnetonka, MN 55343 (US).</p>		<p>(81) Designated States: CA, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p>Published <i>With international search report.</i> <i>With amended claims.</i></p>
<p>(54) Title: IMPROVED STENT CONFIGURATIONS</p> <div data-bbox="284 1134 1339 1491"><p>The diagram illustrates a stent configuration with a repeating pattern of interconnected loops. Label 11 points to a horizontal section of the pattern. Label 12 points to a vertical section. Label 13 points to a specific loop structure. Label 14 points to another loop structure. Label 15 points to a horizontal section of the pattern.</p></div> <p>(57) Abstract</p> <p>Improved stent configurations exhibiting limited recoil, resistance to compression and improved longitudinal flexibility.</p>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

IMPROVED STENT CONFIGURATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 This invention relates to stents of improved configuration.

2. Brief Description of the Prior Art

Stents are radially expandable endoprosthesis which are typically intravascular implants capable of being implanted transluminally and enlarged radially
10 after being introduced percutaneously. They have also been implanted in urinary tracts and bile ducts. They are used to reinforce body vessels and to prevent restenosis following angioplasty in the vascular system. They may be self-expanding or expanded by an internal radial force, such as when mounted on a balloon.

In the past, stents have been generally tubular but have been composed
15 of many configurations and have been made of many materials, including metals and plastic. Ordinary metals such as stainless steel have been used as have shape memory metals such as Nitinol and the like. Stents have also been made of biodegradable plastic materials. Such stents have been formed from wire, tube stock, etc.

20 SUMMARY OF THE INVENTION

This invention provides new configurations of the cells making up stents which may be adapted to all of the various types of prior art stents described above and/or known previously in the art. There are numerous advantages to the new configurations. The configurations of the invention limit recoil and add resistance to
25 compression for an expanded stent, among other things. Other configurations than cylindrical are contemplated, e.g., square, triangular octagonal, etc. The stents of this invention are longitudinally flexible and expandable.

Brief Description of the Figures

30 Figure 1 is a flat plan view of an embodiment of the stent configuration of the invention in the unexpanded condition;

Figure 1a is a fragmentary plan similar to Figure 1 showing a staggered arrangement of the cells making up a stent;

Figures 1b and 1c show cells similar to Figure 1 and 1a in different arrangements and with differing interconnection;

5 Figure 2 is an end view of a stent of Figure 1 according to the invention in its normal tubular unexpanded condition;

Figure 3 is a detail view of a portion of Figure 1, as indicated;

Figure 4 is a view of the stent of Figures 1 and 2 expanded on a balloon;

10 Figure 5 is another stent embodiment of the invention similar in view to Figure 1 showing the flat plan of the stent in the unexpanded configuration;

Figure 6 is a detail view of a portion of Figure 5, as indicated;

Figure 7 is a showing of the stent of Figure 4 expanded on a balloon;

15 Figure 8 is a flat plan similar to Figures 1 and 5 showing another stent embodiment in the unexpanded condition;

Figure 8a is a plan view in fragment showing a variation of the cell configuration shown in Figure 8;

Figure 9 is a detail view of a portion of Figure 8, as indicated;

Figure 10 is a showing of the stent of Figure 8 expanded on a balloon;

20 Figure 11 is a flat plan similar to Figures 1, 5, and 8 showing yet another stent embodiment in the unexpanded condition;

Figure 12 is a detail view of a portion of Figure 11, as indicated;

Figure 13 is a view of the stent of Figure 11 on an unexpanded balloon demonstrating its flexibility in the unexpanded condition;

25 Figure 14 is a showing of the stent of Figure 11 expanded on a balloon;

Figure 15 is a flat plan similar to Figures 1, 5, 8, and 11 showing yet another stent embodiment in the unexpanded condition;

Figure 16 is a detail view of a portion of Figure 15, as indicated;

Figure 17 is a showing of the stent of Figure 15 expanded on a balloon;

30 Figure 18 is a flat plan similar to Figures 1, 5, 8, 11 and 15 showing still another stent embodiment in the unexpanded condition;

Figure 19 is a detail view of a portion of Figure 18, as indicated;

Figure 20 is a flat plan view similar to Figures 1, 5, 8, 11, 15 and 18 showing yet another stent embodiment in the unexpanded condition;

Figure 21 is a detail view of a portion of Figure 20, and

Figure 22 is a flat plan view of another embodiment of the invention.

5

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment of a generally cylindrical stent 10 according to the invention is illustrated in Figures 1-4. It comprises a metal tube as shown in Figures 2 and 4, such as nitinol or stainless steel preferably, which has been etched or
10 preferably laser cut to the configuration shown in the flat plan view of Figure 1. An enlarged detail of Figure 1 is shown in Figure 3. The configuration is made up of a series of curvilinear expansion cell elements generally indicated at 12 (see darkened example in Figure 3 for clarity) having relatively wide end portions 14 joined by relatively narrow center portions 16. Cells 12 are arranged longitudinally as shown in
15 Figure 1 end to end with respect to the longitudinal axis of the stent 10 and in substantially parallel rows as also shown in Figure 1. A plurality of longitudinally extending elongate support members 18 are included, one each being disposed between adjacent rows of cells 12. Also, a plurality of circumferentially extending support members 19, preferably substantially normal to support members 18 are also
20 positioned between the rows of cells 12 to intersect portions of the support members 18 and to interconnect them to the narrow center portions 16 of cells 12. As can be seen in Figure 1a, cells 12 may also be arranged in a staggered arrangement. Figures 1b and 1c demonstrate different arrangements and interconnections for cells 12.

When the stent is expanded, as shown in Figure 4, on a balloon 20 the
25 cells 12 take on a new configuration as shown, the members making up the stent being indicated by the same numbers as used in Figure 1 and Figure 3. Again, one cell is shown darkened for clarity.

Referring now to Figures 5-7, another stent embodiment generally indicated at 22 of the invention is shown. In this embodiment, as seen in Figures 5
30 and 6, expansion cells 24, best seen in the detail of Figure 6 and indicated by darkened portion, have relatively wide end portions 26, best seen in Figure 6, and narrow center portions 28 and are arranged end to end in longitudinal rows as

described with respect to the first embodiment. Adjacent end portions 26 are interconnected by pairs of longitudinal support members in the form of segments 30 which have curved end portions 32. Circumferential extending segments 34 extend between rows of cells 24 to interconnect the narrow center portions 28.

5 Upon radial expansion of the stent, as on a balloon 20 for example, its configuration changes by deformation force in the directions shown by the arrows in Figure 6 to that configuration shown in Figure 7. The elements indicated in Figure 7 are identified by the same numbers indicated for similar elements in Figures 5 and 6.

 Figures 20 and 21 show a configuration somewhat similar to that of
10 Figures 5-7 but without interconnecting elements 28.

 Referring now to Figures 8-10, another stent embodiment of the invention is shown and generally indicated at 40. Again, as seen in Figures 8 and 9, expansion cells 42 (example darkened for clarity) have relatively wide end portions 44 and narrow center portions 46. The end portions include inwardly extending loop
15 portions 48. Cells 42 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 44 are interconnected by pairs of longitudinal support member segments 50 which have curved end portions 52. Circumferentially extending segments 54 extend between rows of cells 42 to interconnect the narrow center portions 46 of the cells. Figure 8a shows a variation in shape for cells 42.

20 Upon radial expansion of the stent upon a balloon 20, the configuration changes to that shown in Figure 10. The arrows show the direction of force of deformation upon expansion.

 Referring now to Figures 11 and 12, still another embodiment of a stent 60 is shown. Again, as shown in Figures 11 and 12, expansion cells 62 (example
25 darkened for clarity) have relatively wide end portions 64 having a slight inward bend 65 to them and narrow center portions 66. Cells 62 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 64 are interconnected by pairs of longitudinal support member segments 68 which have curved end portions 70. Circumferentially extending segments 72 extend between
30 rows of cells 62 to interconnect the narrow center portions 66 of the cells.

 Reference to Figure 13 will show the inherent flexibility of the stents of this invention.

Upon radial expansion of the stent upon a balloon 20, the configuration changes to that shown in Figure 14.

Referring now to Figures 15 and 16, yet another embodiment of a stent 80 is shown in a configuration quite similar to that of Figures 11-14 but with an added circumferentially extending structural element 81. Again, as best seen in Figure 16, expansion cells 82 (examples darkened for clarity) have relatively wide end portions 84 having a slight inward bend 85 to them and narrow center portions 86. Cells 82 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 84 are interconnected by pairs of longitudinal support member segments 88 which have curved end portions 90. Circumferentially extending segments 92 extend between rows of cells 82 to interconnect the narrow center portions 86 of the cells. Circumferentially extending segments 81 interconnect pairs of support member segments 88.

Upon radial expansion of the stent on a balloon 20, the configuration changes to that shown in Figure 17.

Referring now to Figures 18 and 19, still another embodiment of a stent configuration 100 is shown. As before this embodiment is similar to that of Figures 11-12 except that the circumferentially extending segments 101 are arranged differently than those identified in Figures 11-12 as 72. In this embodiment the circumferentially extending members 101 extend between the adjacent ends of adjacent cells 103 (examples darkened for clarity) to interconnect the top of one end to the bottom of the adjacent end and the members 101 have a slight curve or bend 105 in their length. The other members are all similarly numbered as in the preceding Figures.

Figure 22 shows yet another embodiment of a stent comprised of cells 120 having interconnecting circumferential extending members 122. The cells have common sides or end members 124 and are arranged in groups to form bands 126 which are interconnected by joined cells 128.

While this invention may be embodied in many different forms, there are described in detail herein specific preferred embodiments of the invention. This description is an exemplification of the principles of the invention and is not intended to limit the invention to the particular embodiments illustrated.

The above Examples and disclosure are intended to be illustrative and not exhaustive. These examples and description will suggest many variations and alternatives to one of ordinary skill in this art. All these alternatives and variations are intended to be included within the scope of the attached claims. Those familiar
5 with the art may recognize other equivalents to the specific embodiments described herein which equivalents are also intended to be encompassed by the claims attached hereto.

What is claimed is as follows:

1. A stent of generally cylindrical shape made up of a plurality of regularly arranged curvilinear bodies of same shape providing closed expansion cells, the cells
5 having relatively wide end portions joined by a relatively narrow center portion and being arranged longitudinally in rows with respect to the longitudinal axis of the stent.
2. The stent of claim 1 wherein the curvilinear bodies are also arranged in substantially parallel longitudinal rows end to end and there is included;
a plurality of longitudinal support members positioned between the
10 longitudinal rows of cells, and
a plurality of circumferentially extending connecting members substantially normal to the support members and interconnecting them to the narrow center portions of the cells.
3. The stent of claim 1 wherein the rows of cells are substantially parallel
15 and the cells are in alignment circumferentially.
4. The stent of claim 3 wherein the cells are staggered circumferentially.
5. A stent of generally cylindrical shape made up of
a plurality of curvilinear bodies providing closed expansion cells, the cells being formed of relatively wide end portions and narrow center portions and being arranged in
20 longitudinal rows around the periphery of the stent and end to end in each row;
paired longitudinal connecting members connecting the ends of adjacent cells, and
circumferentially extending members extending between cells of adjacent rows and interconnecting the cells at the narrow portions.
- 25 6. The stent of claim 5 including members which extend between adjacent cell ends interconnecting the top of one cell end to the bottom of another.
7. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies of same shape providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion and
30 being arranged longitudinally with respect to the longitudinal axis of the stent.
8. The stent of claim 7 wherein the bodies are also arranged in substantially parallel longitudinal rows end to end.

9. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion.

AMENDED CLAIMS

[received by the International Bureau on 25 March 1999 (25.03.99);
original claims 1,2 and 5 amended; original claims 7-9 replaced by new claims 7-10
remaining claims unchanged (2 pages)]

What is claimed is as follows:

1. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion, the cells arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, longitudinally adjacent cells interconnected by connection members.
2. The stent of claim 1 wherein the longitudinal rows are substantially parallel, the stent further comprising
a plurality of longitudinal extending elongate support members, adjacent longitudinal rows of cells joined by at least one elongate support member, and
a plurality of circumferentially extending connecting members
substantially normal to the support members and interconnecting the support members to the narrow center portions of the cells.
3. The stent of claim 1 wherein the rows of cells are substantially parallel and the cells are in alignment circumferentially.
4. The stent of claim 3 wherein the cells are staggered circumferentially.
5. A stent of generally cylindrical shape comprising of a plurality of curvilinear bodies providing closed expansion cells, the cells being formed of relatively wide end portions and relatively narrow center portions and being arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent;
paired longitudinally connecting members connecting the ends of adjacent cells, and
circumferentially extending members extending between cells of adjacent rows and interconnecting the cells at the narrow portions.
6. The stent of claim 5 including members which extend between adjacent cell ends interconnecting the top of one cell end to the bottom of another.
7. The stent of claim 1 wherein the relatively wide end dimensions are further characterized as being substantially identical to each other.
8. The stent of claim 1 wherein the cells are symmetrical in overall shape.
9. A stent of generally cylindrical shape and having a longitudinal axis and a circumference, the stent comprised of a plurality of regularly arranged interconnected curvilinear bodies individual closed expansion cells, the cells having

AMENDED SHEET (ARTICLE 19)

relatively wide end portions joined by a relatively narrow center portion, some of the cells arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, and some of the cells arranged circumferentially in circumferential rows with respect to the circumference of the stent.

10. A stent of generally cylindrical shape and having a longitudinal axis comprised of a plurality of bands which are made up of a plurality of regularly arranged interconnected curvilinear bodies of same shape providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion and being arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, the bands being interconnected by the curvilinear bodies shared between certain expansion cells located on adjacent edges of the bands, the certain cells being less than the number of cells which make up the band edges.

AMENDED SHEET (ARTICLE 19)

Fig. 1

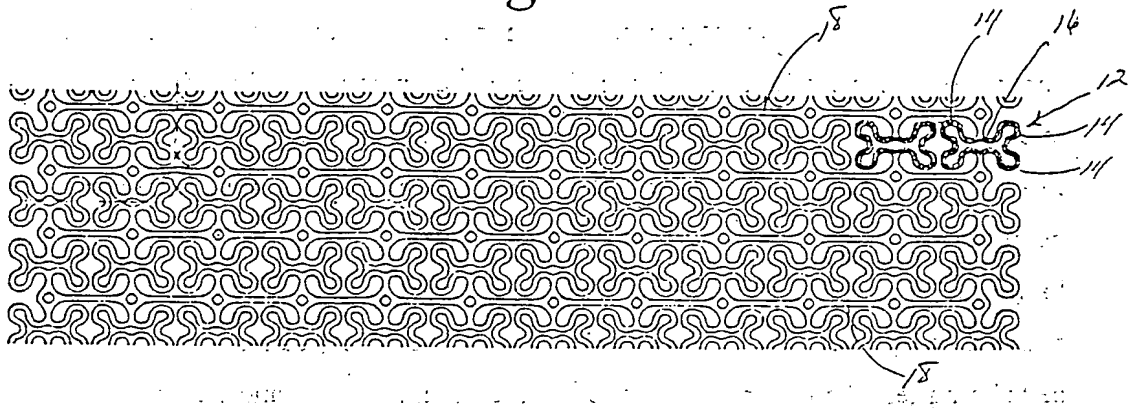


Fig. 2

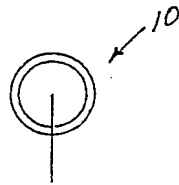


Fig. 3

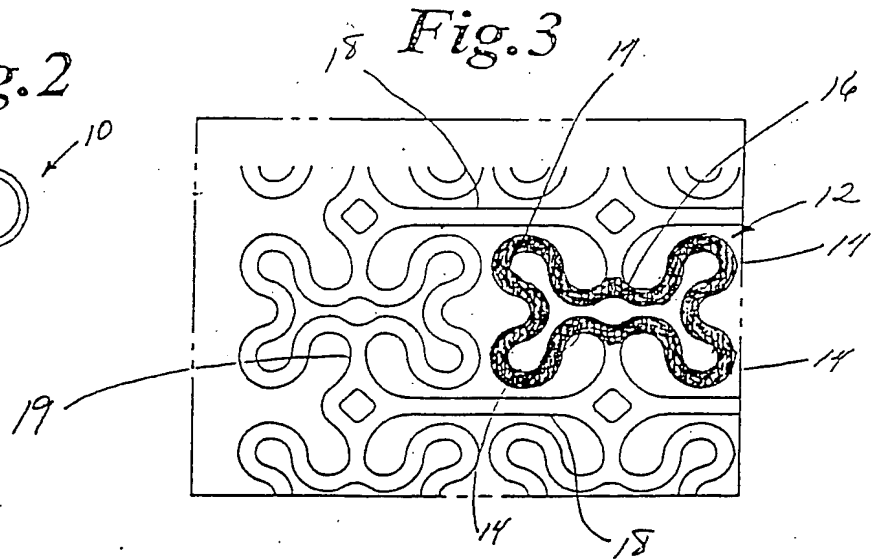
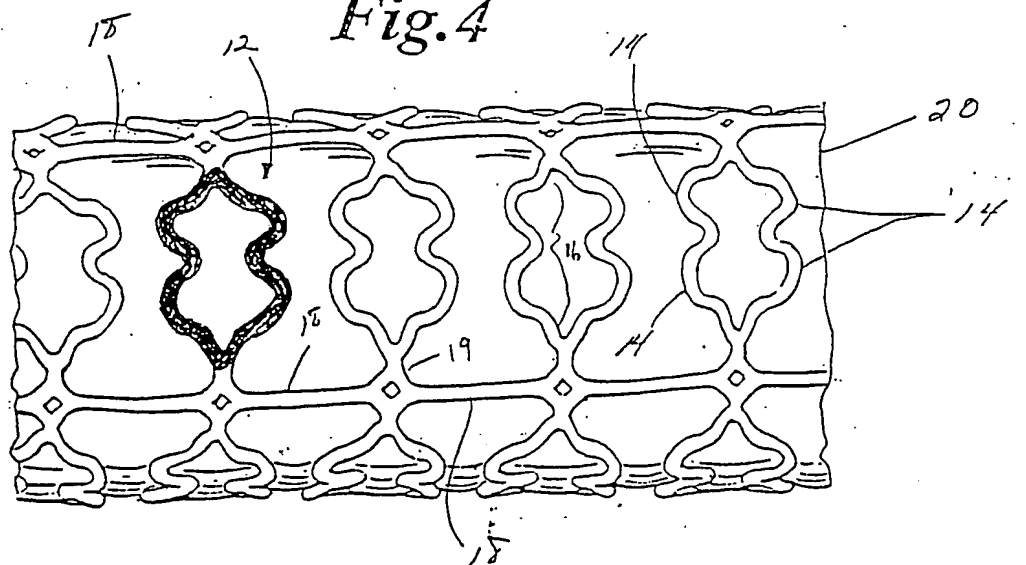
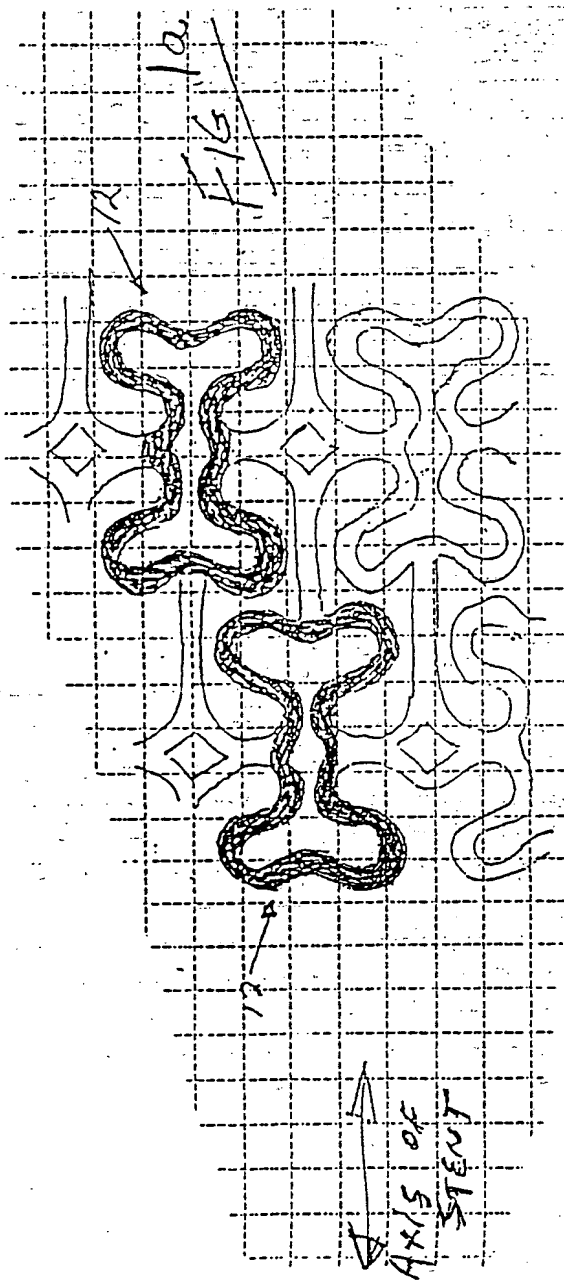


Fig. 4





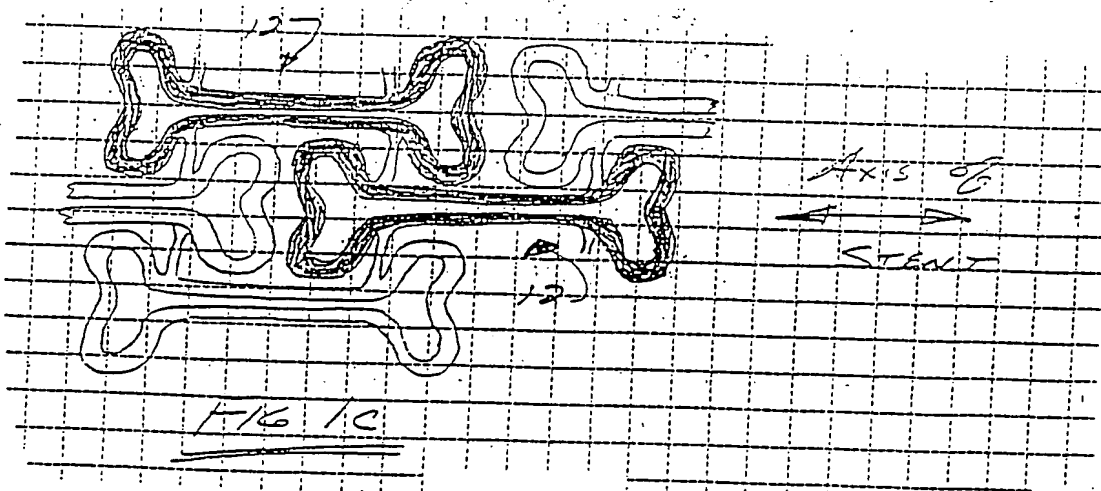
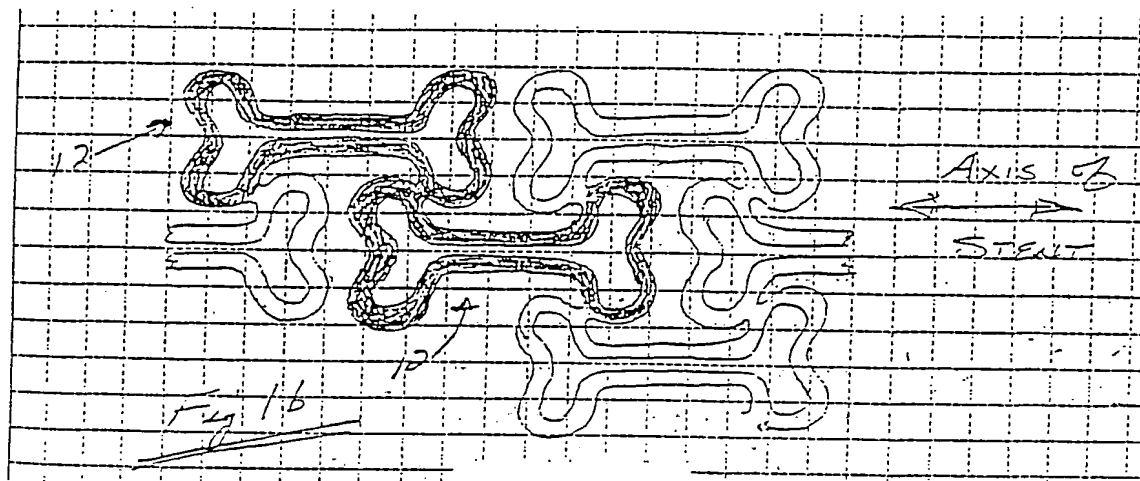


Fig. 5

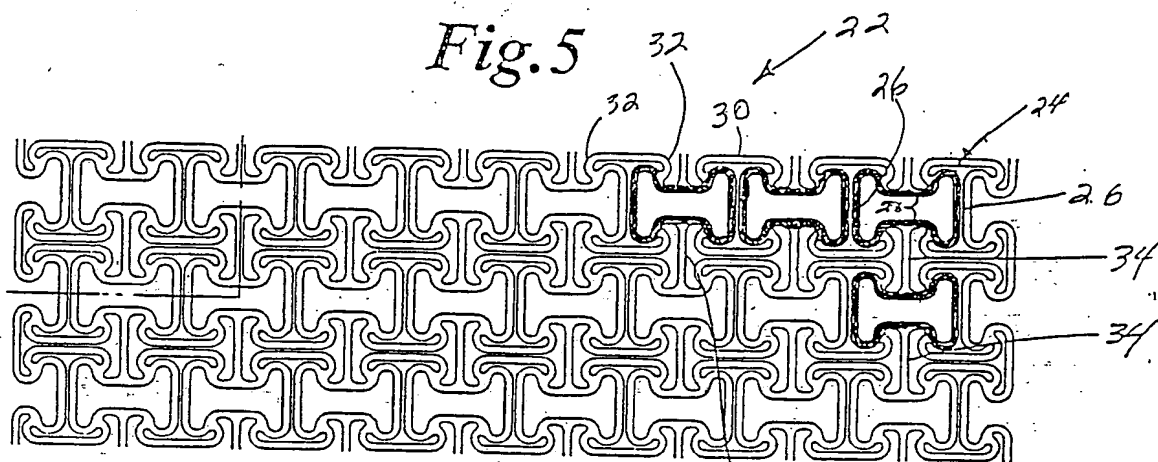


Fig. 6

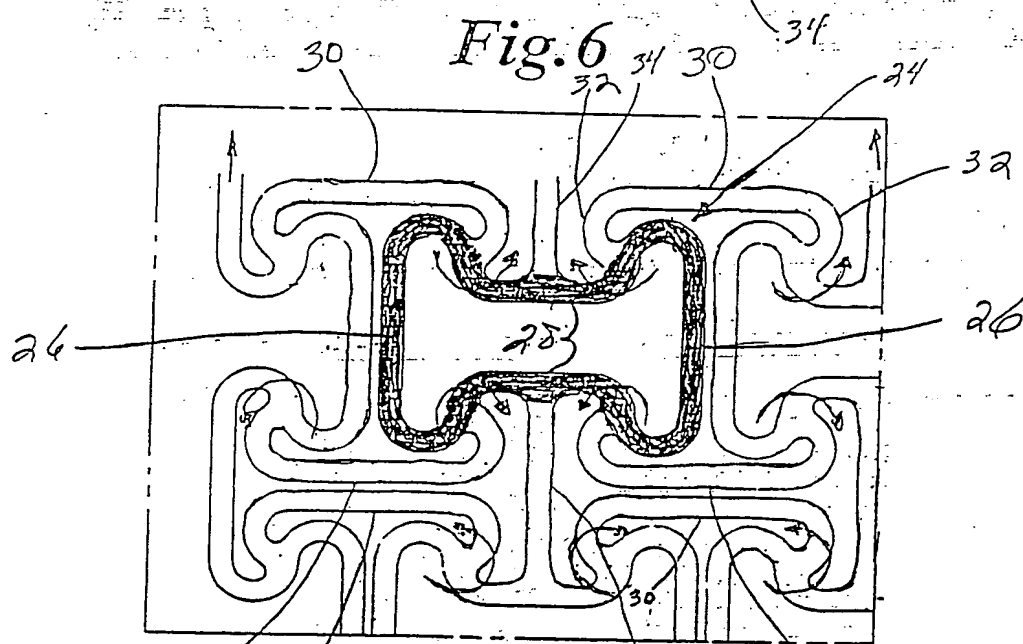


Fig. 7

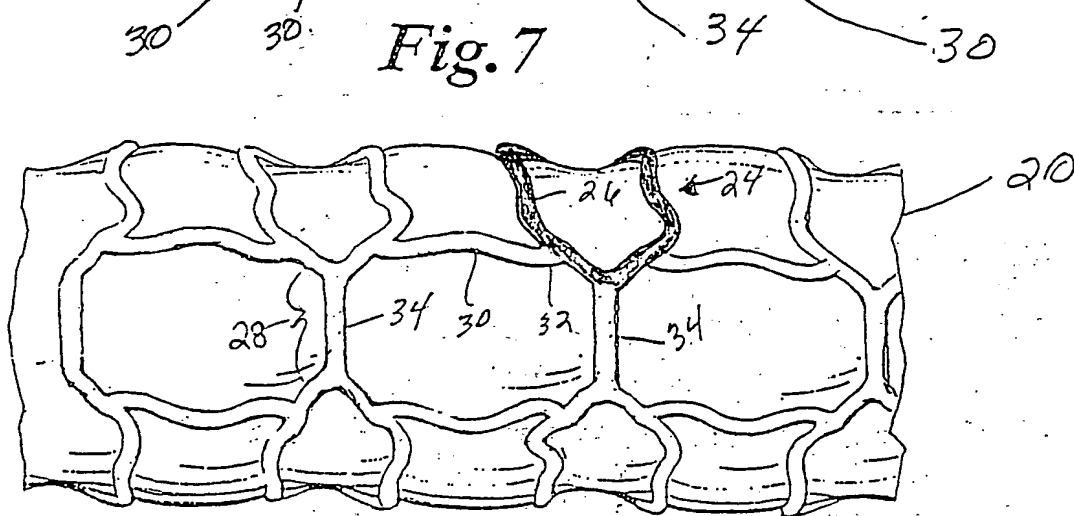


Fig. 8

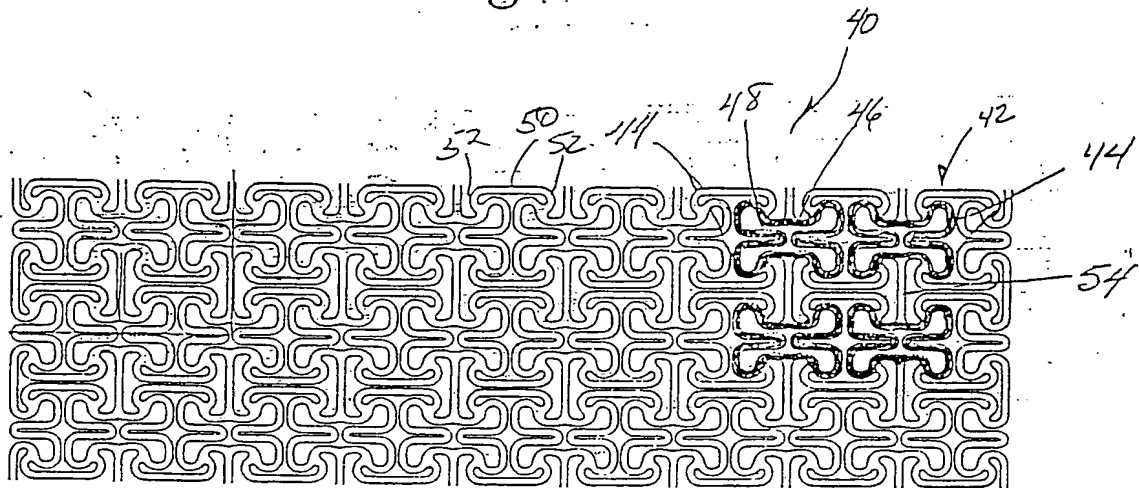


Fig. 9

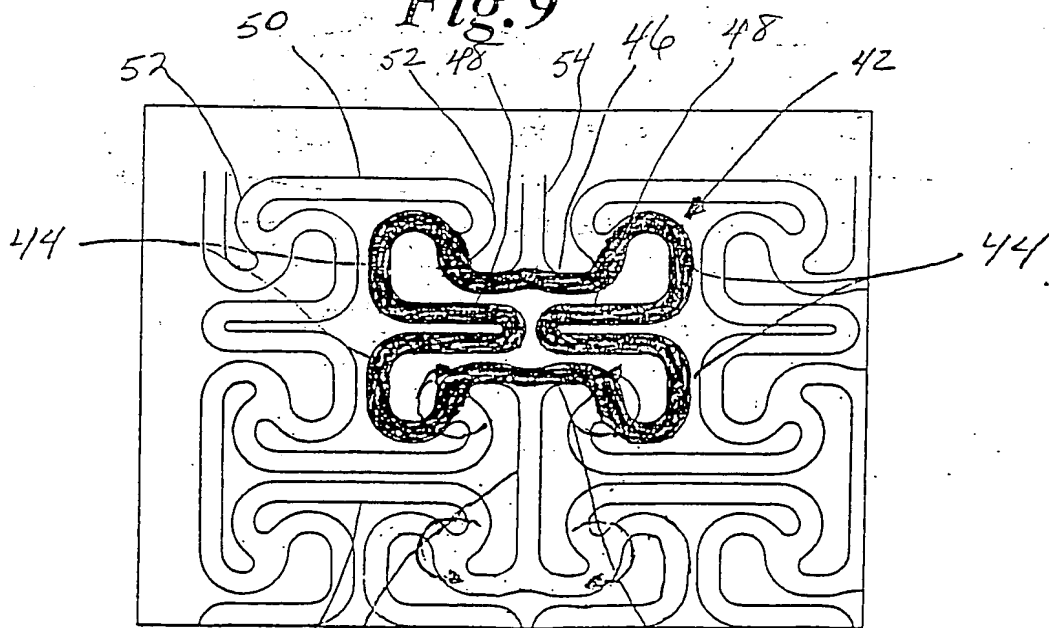
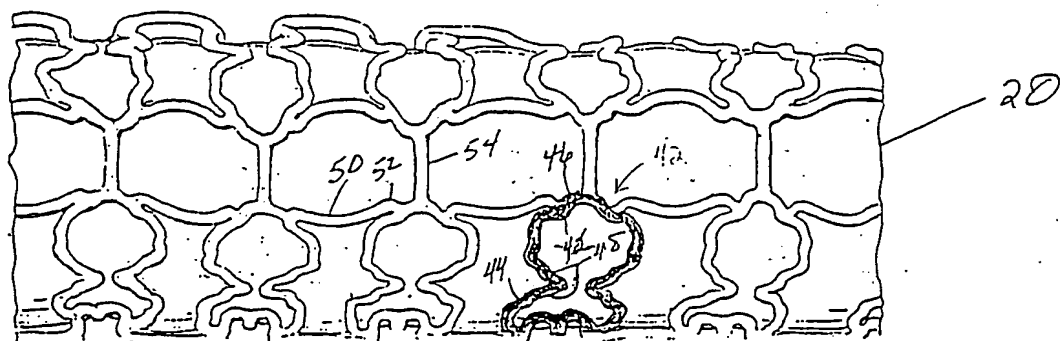


Fig. 10



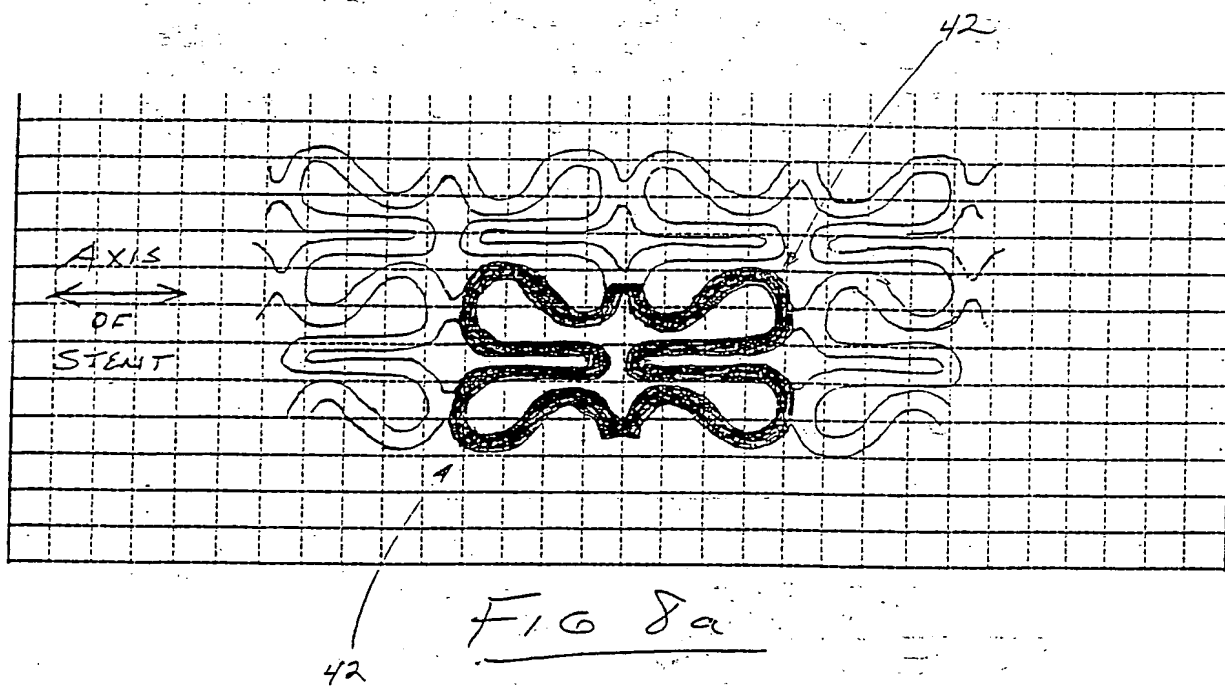


Fig. 11

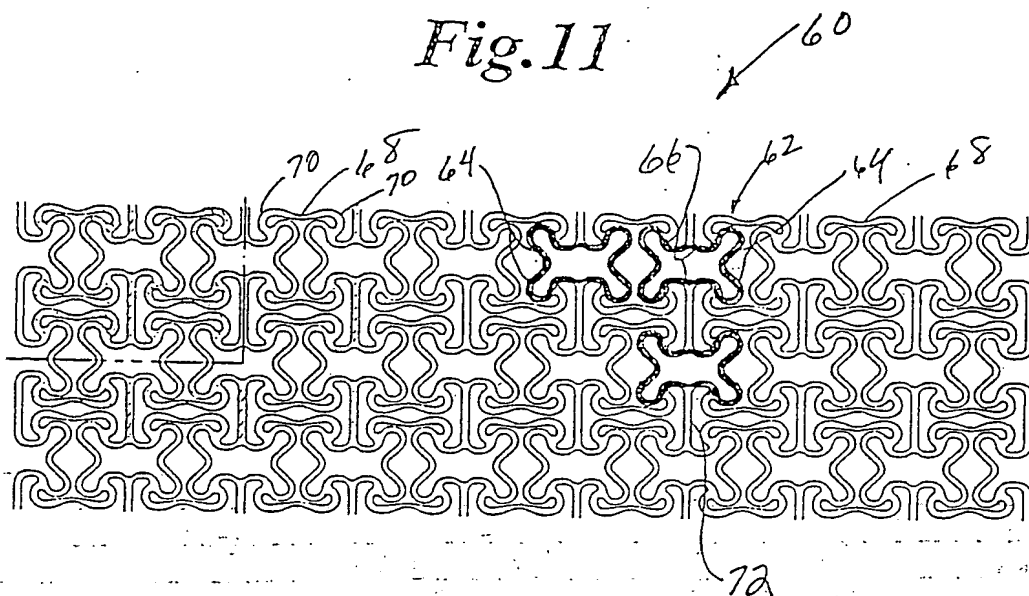
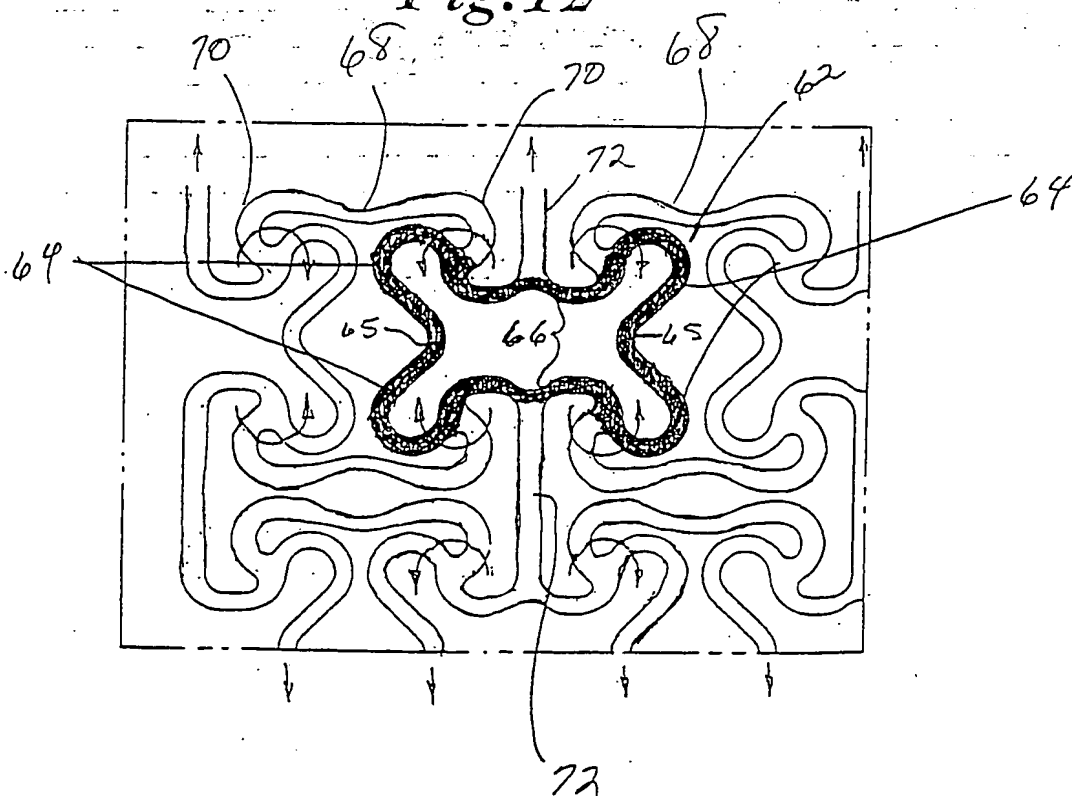


Fig. 12



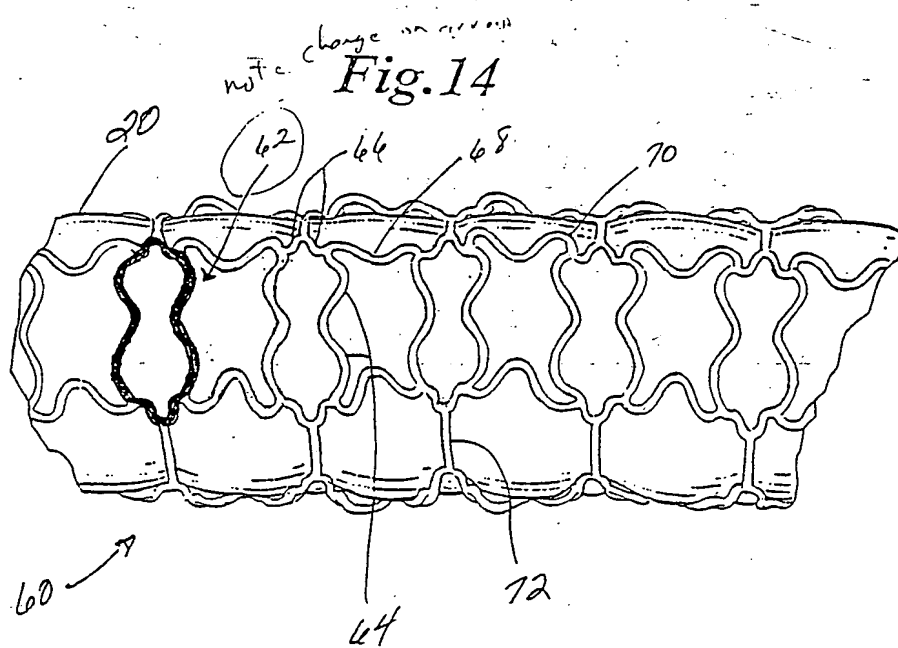
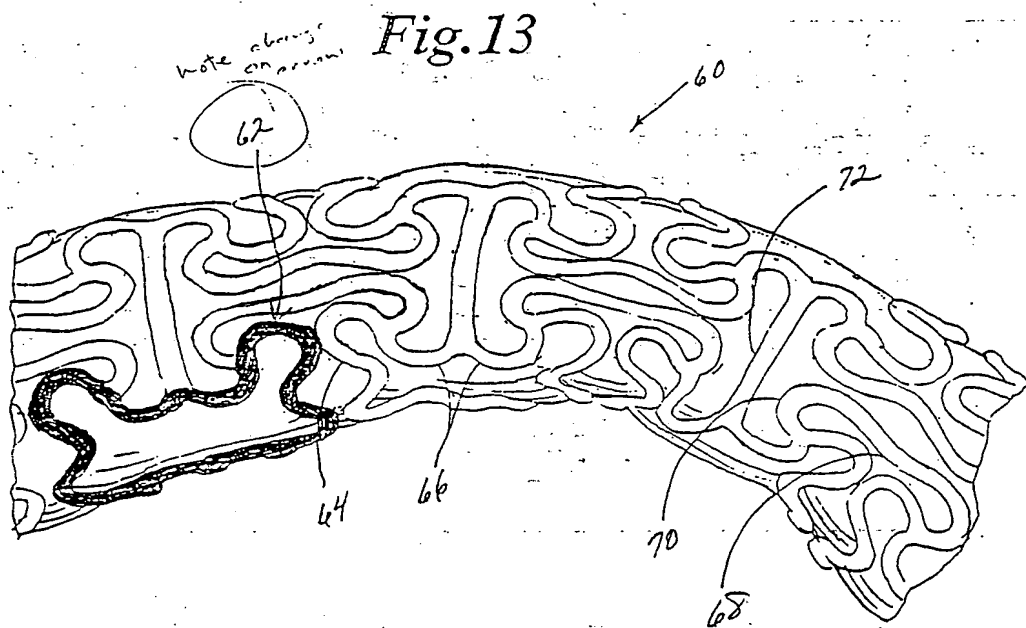


Fig. 15

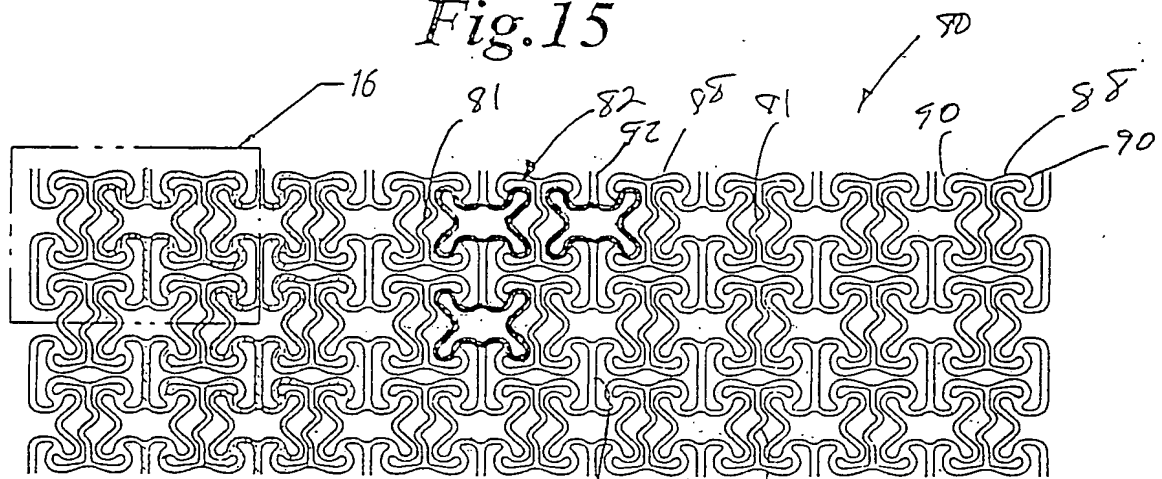


Fig. 16

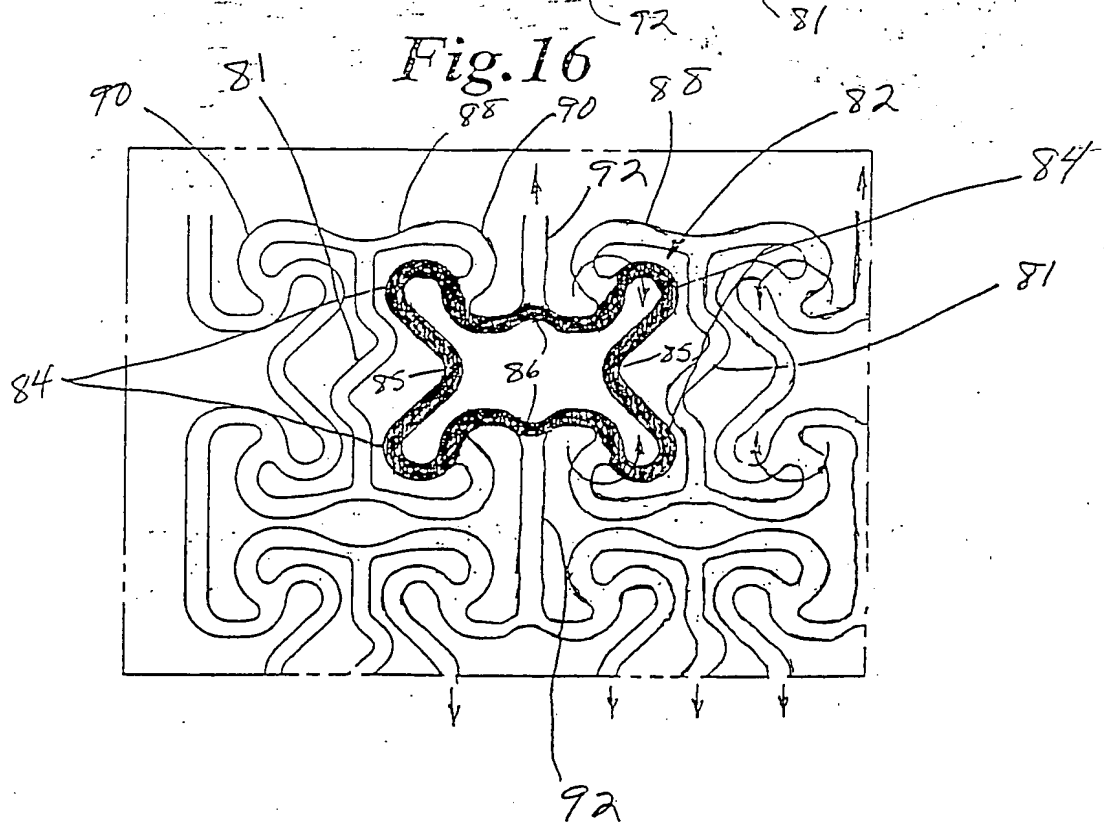


Fig. 17

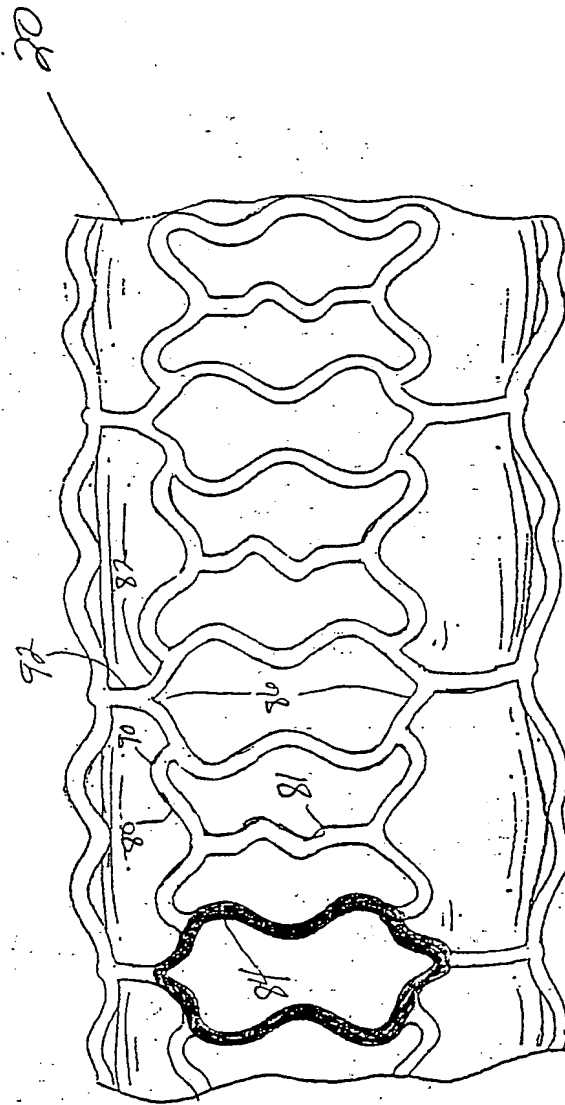


Fig. 18

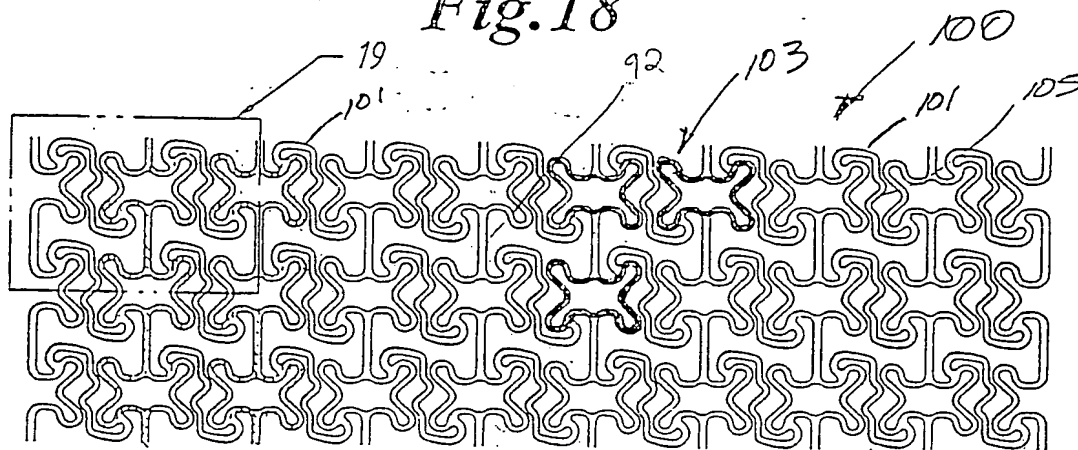
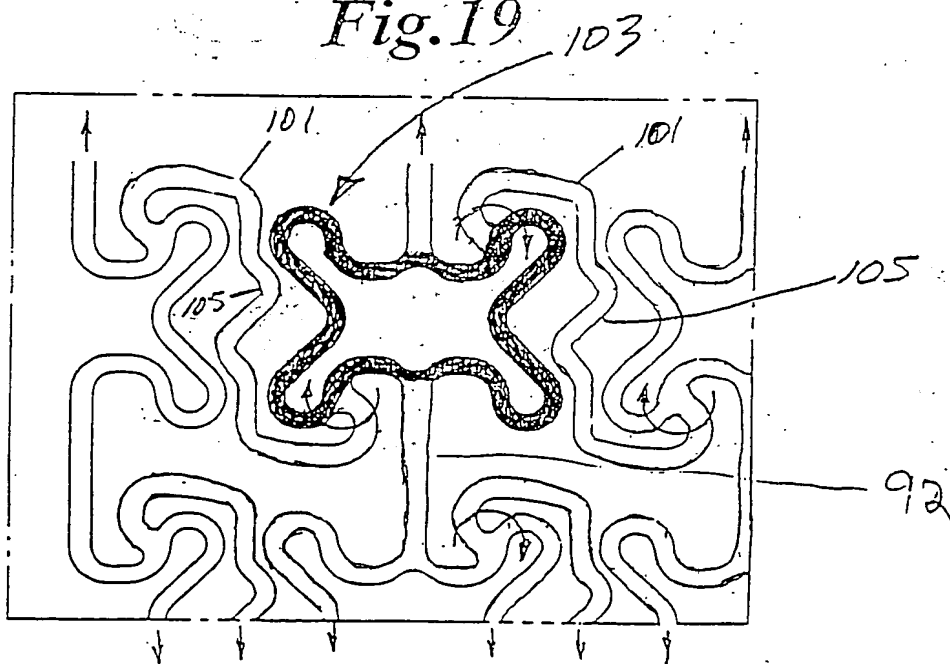


Fig. 19



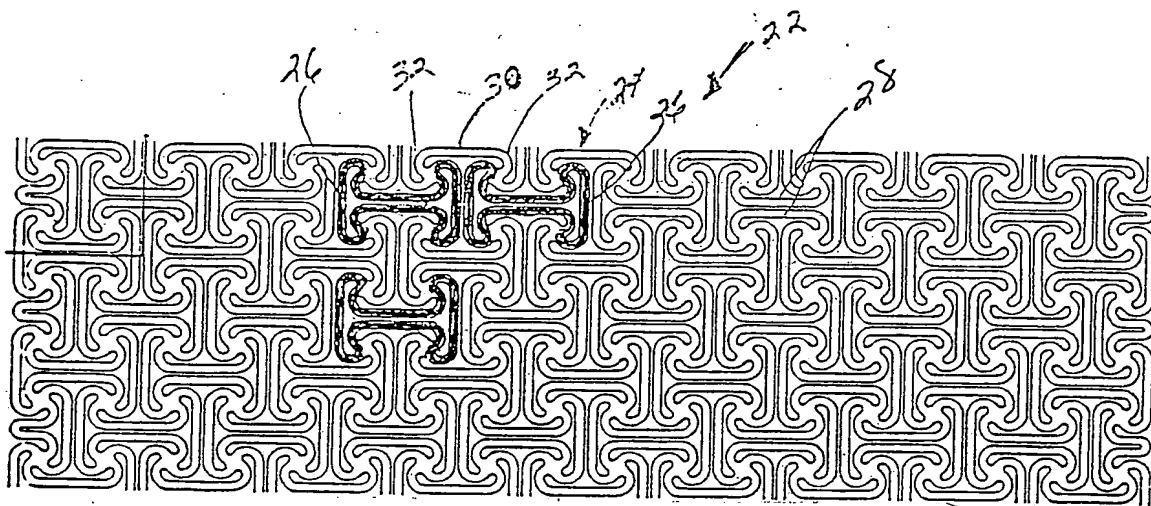
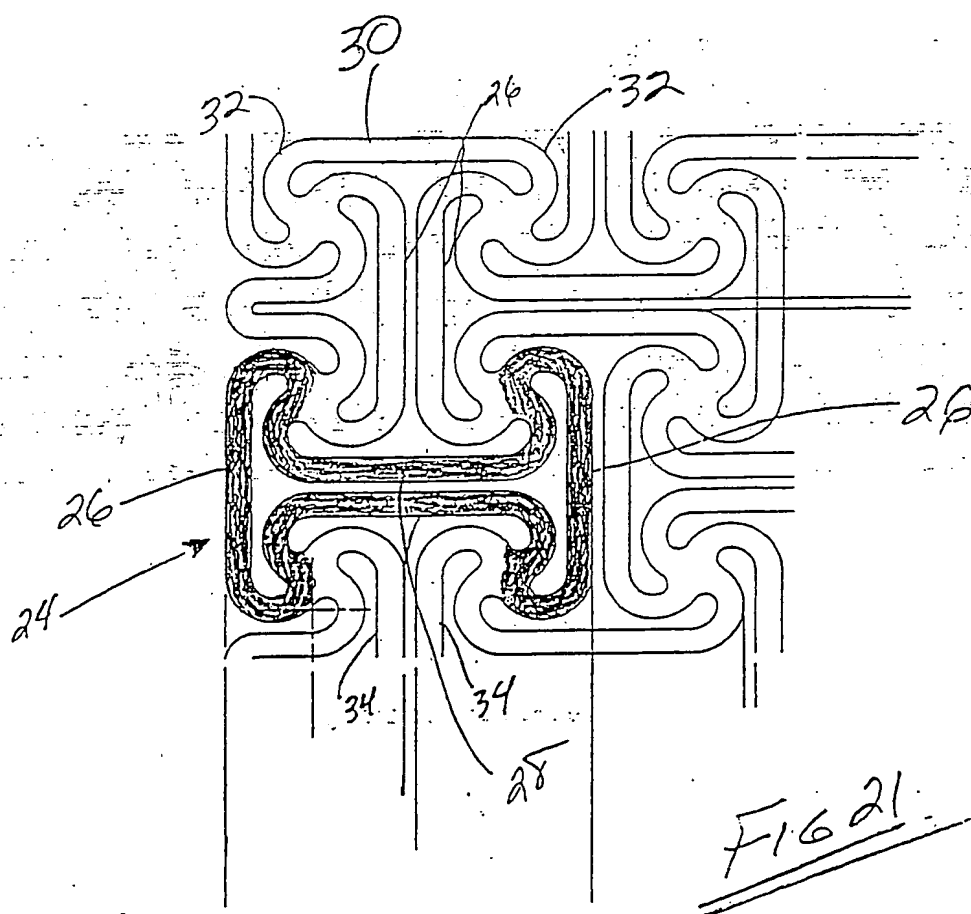
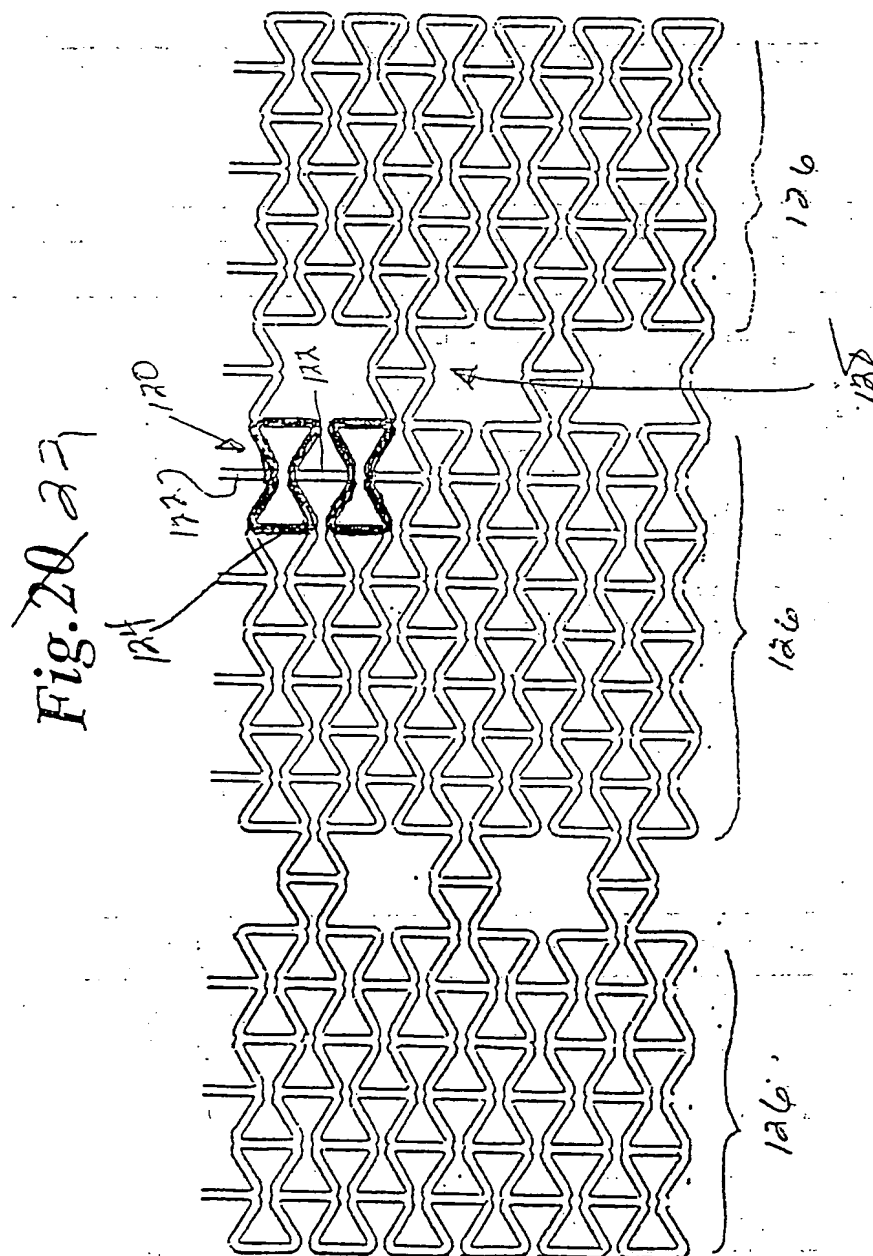


Fig. 20.





INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/21106

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61F2/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 669 932 A (FISCHELL ET AL) 23 September 1997 see column 4, line 64 - column 5, line 48; figure 8	1, 3, 5; 7-9
X	WO 97 33534 A (MEDTRONIC, INC.) 18 September 1997 see figure 1	1, 3, 7-9
X	WO 95 09584 A (GUERBET S.A.) 13 April 1995 see abstract; figures	7, 9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

22 January 1999

Date of mailing of the international search report

01/02/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Smith, C

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/US 98/21106

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5669932	A	23-09-1997	NONE
WO 9733534	A	18-09-1997	AU 2208797 A 01-10-1997 EP 0891166 A 20-01-1999
WO 9509584	A	13-04-1995	FR 2710834 A 14-04-1995 AT 162065 T 15-01-1998 AU 7858594 A 01-05-1995 CA 2173500 A 13-04-1995 DE 69407984 D 19-02-1998 DE 69407984 T 03-09-1998 EP 0722304 A 24-07-1996 ES 2115262 T 16-06-1998 JP 9503141 T 31-03-1997



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification⁶ : A61F 2/06</p>	<p>A1</p>	<p>(11) International Publication Number: WO 99/18888 (43) International Publication Date: 22 April 1999 (22.04.99)</p>
<p>(21) International Application Number: PCT/US98/21106 (22) International Filing Date: 6 October 1998 (06.10.98) (30) Priority Data: 08/947,620 9 October 1997 (09.10.97) US (71) Applicant: SCIMED LIFE SYSTEMS, INC., [US/US]; One Scimed Place, Maple Grove, MN 55311 (US). (72) Inventors: LEY, Timothy, J.; 668 Highway 96 West, Shoreview, MN 55126 (US). KVEEN, Graig, L.; 14125 74th Place North, Maple Grove, MN 55311 (US). EHR, Timothy, G., J.; 19017 Zane Street N.W., Elk River, MN 55330 (US). BROWN, Brian, J.; 178 Jandel Avenue N.E., Hanover, MN 55341 (US). FRIESEN, David, L.; 8149 Sierra Parkway, Brooklyn Park, MN 55444 (US). (74) Agents: ARRETT, Oliver, F. et al.; 6109 Blue Circle Drive, Minnetonka, MN 55343 (US).</p>		<p>(81) Designated States: CA, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>With amended claims.</i></p>
<p>(54) Title: IMPROVED STENT CONFIGURATIONS</p> <div data-bbox="349 1144 1372 1491"> </div> <p>(57) Abstract Improved stent configurations exhibiting limited recoil, resistance to compression and improved longitudinal flexibility.</p>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav. Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

IMPROVED STENT CONFIGURATIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 This invention relates to stents of improved configuration.

2. Brief Description of the Prior Art

Stents are radially expandable endoprosthesis which are typically intravascular implants capable of being implanted transluminally and enlarged radially after being introduced percutaneously. They have also been implanted in urinary tracts and bile ducts. They are used to reinforce body vessels and to prevent restenosis following angioplasty in the vascular system. They may be self-expanding or expanded by an internal radial force, such as when mounted on a balloon.

In the past, stents have been generally tubular but have been composed of many configurations and have been made of many materials, including metals and plastic. Ordinary metals such as stainless steel have been used as have shape memory metals such as Nitinol and the like. Stents have also been made of biodegradable plastic materials. Such stents have been formed from wire, tube stock, etc.

SUMMARY OF THE INVENTION

This invention provides new configurations of the cells making up stents which may be adapted to all of the various types of prior art stents described above and/or known previously in the art. There are numerous advantages to the new configurations. The configurations of the invention limit recoil and add resistance to compression for an expanded stent, among other things. Other configurations than cylindrical are contemplated, e.g., square, triangular octagonal, etc. The stents of this invention are longitudinally flexible and expandable.

Brief Description of the Figures

30 Figure 1 is a flat plan view of an embodiment of the stent configuration of the invention in the unexpanded condition;

Figure 1a is a fragmentary plan similar to Figure 1 showing a staggered arrangement of the cells making up a stent;

Figures 1b and 1c show cells similar to Figure 1 and 1a in different arrangements and with differing interconnection;

5 Figure 2 is an end view of a stent of Figure 1 according to the invention in its normal tubular unexpanded condition;

Figure 3 is a detail view of a portion of Figure 1, as indicated;

Figure 4 is a view of the stent of Figures 1 and 2 expanded on a balloon;

10 Figure 5 is another stent embodiment of the invention similar in view to Figure 1 showing the flat plan of the stent in the unexpanded configuration;

Figure 6 is a detail view of a portion of Figure 5, as indicated;

Figure 7 is a showing of the stent of Figure 4 expanded on a balloon;

Figure 8 is a flat plan similar to Figures 1 and 5 showing another stent
15 embodiment in the unexpanded condition;

Figure 8a is a plan view in fragment showing a variation of the cell configuration shown in Figure 8;

Figure 9 is a detail view of a portion of Figure 8, as indicated;

Figure 10 is a showing of the stent of Figure 8 expanded on a balloon;

20 Figure 11 is a flat plan similar to Figures 1, 5, and 8 showing yet another stent embodiment in the unexpanded condition;

Figure 12 is a detail view of a portion of Figure 11, as indicated;

Figure 13 is a view of the stent of Figure 11 on an unexpanded balloon demonstrating its flexibility in the unexpanded condition;

25 Figure 14 is a showing of the stent of Figure 11 expanded on a balloon;

Figure 15 is a flat plan similar to Figures 1, 5, 8, and 11 showing yet another stent embodiment in the unexpanded condition;

Figure 16 is a detail view of a portion of Figure 15, as indicated;

Figure 17 is a showing of the stent of Figure 15 expanded on a balloon;

30 Figure 18 is a flat plan similar to Figures 1, 5, 8, 11 and 15 showing still another stent embodiment in the unexpanded condition;

Figure 19 is a detail view of a portion of Figure 18, as indicated;

Figure 20 is a flat plan view similar to Figures 1, 5, 8, 11, 15 and 18 showing yet another stent embodiment in the unexpanded condition;

Figure 21 is a detail view of a portion of Figure 20, and

Figure 22 is a flat plan view of another embodiment of the invention.

5

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment of a generally cylindrical stent 10 according to the invention is illustrated in Figures 1-4. It comprises a metal tube as shown in Figures 2 and 4, such as nitinol or stainless steel preferably, which has been etched or preferably laser cut to the configuration shown in the flat plan view of Figure 1. An enlarged detail of Figure 1 is shown in Figure 3. The configuration is made up of a series of curvilinear expansion cell elements generally indicated at 12 (see darkened example in Figure 3 for clarity) having relatively wide end portions 14 joined by relatively narrow center portions 16. Cells 12 are arranged longitudinally as shown in Figure 1 end to end with respect to the longitudinal axis of the stent 10 and in substantially parallel rows as also shown in Figure 1. A plurality of longitudinally extending elongate support members 18 are included, one each being disposed between adjacent rows of cells 12. Also, a plurality of circumferentially extending support members 19, preferably substantially normal to support members 18 are also positioned between the rows of cells 12 to intersect portions of the support members 18 and to interconnect them to the narrow center portions 16 of cells 12. As can be seen in Figure 1a, cells 12 may also be arranged in a staggered arrangement. Figures 1b and 1c demonstrate different arrangements and interconnections for cells 12.

When the stent is expanded, as shown in Figure 4, on a balloon 20 the cells 12 take on a new configuration as shown, the members making up the stent being indicated by the same numbers as used in Figure 1 and Figure 3. Again, one cell is shown darkened for clarity.

Referring now to Figures 5-7, another stent embodiment generally indicated at 22 of the invention is shown. In this embodiment, as seen in Figures 5 and 6, expansion cells 24, best seen in the detail of Figure 6 and indicated by darkened portion, have relatively wide end portions 26, best seen in Figure 6, and narrow center portions 28 and are arranged end to end in longitudinal rows as

described with respect to the first embodiment. Adjacent end portions 26 are interconnected by pairs of longitudinal support members in the form of segments 30 which have curved end portions 32. Circumferential extending segments 34 extend between rows of cells 24 to interconnect the narrow center portions 28.

5 Upon radial expansion of the stent, as on a balloon 20 for example, its configuration changes by deformation force in the directions shown by the arrows in Figure 6 to that configuration shown in Figure 7. The elements indicated in Figure 7 are identified by the same numbers indicated for similar elements in Figures 5 and 6.

 Figures 20 and 21 show a configuration somewhat similar to that of
10 Figures 5-7 but without interconnecting elements 28.

 Referring now to Figures 8-10, another stent embodiment of the invention is shown and generally indicated at 40. Again, as seen in Figures 8 and 9, expansion cells 42 (example darkened for clarity) have relatively wide end portions 44 and narrow center portions 46. The end portions include inwardly extending loop
15 portions 48. Cells 42 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 44 are interconnected by pairs of longitudinal support member segments 50 which have curved end portions 52. Circumferentially extending segments 54 extend between rows of cells 42 to interconnect the narrow center portions 46 of the cells. Figure 8a shows a variation in shape for cells 42.

20 Upon radial expansion of the stent upon a balloon 20, the configuration changes to that shown in Figure 10. The arrows show the direction of force-of deformation upon expansion.

 Referring now to Figures 11 and 12, still another embodiment of a stent 60 is shown. Again, as shown in Figures 11 and 12, expansion cells 62 (example
25 darkened for clarity) have relatively wide end portions 64 having a slight inward bend 65 to them and narrow center portions 66. Cells 62 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 64 are interconnected by pairs of longitudinal support member segments 68 which have curved end portions 70. Circumferentially extending segments 72 extend between
30 rows of cells 62 to interconnect the narrow center portions 66 of the cells.

 Reference to Figure 13 will show the inherent flexibility of the stents of this invention.

Upon radial expansion of the stent upon a balloon 20, the configuration changes to that shown in Figure 14.

Referring now to Figures 15 and 16, yet another embodiment of a stent 80 is shown in a configuration quite similar to that of Figures 11-14 but with an added circumferentially extending structural element 81. Again, as best seen in Figure 16, expansion cells 82 (examples darkened for clarity) have relatively wide end portions 84 having a slight inward bend 85 to them and narrow center portions 86. Cells 82 are arranged end to end in longitudinal rows as in the preceding embodiments. Adjacent end portions 84 are interconnected by pairs of longitudinal support member segments 88 which have curved end portions 90. Circumferentially extending segments 92 extend between rows of cells 82 to interconnect the narrow center portions 86 of the cells. Circumferentially extending segments 81 interconnect pairs of support member segments 88.

Upon radial expansion of the stent on a balloon 20, the configuration changes to that shown in Figure 17.

Referring now to Figures 18 and 19, still another embodiment of a stent configuration 100 is shown. As before this embodiment is similar to that of Figures 11-12 except that the circumferentially extending segments 101 are arranged differently than those identified in Figures 11-12 as 72. In this embodiment the circumferentially extending members 101 extend between the adjacent ends of adjacent cells 103 (examples darkened for clarity) to interconnect the top of one end to the bottom of the adjacent end and the members 101 have a slight curve or bend 105 in their length. The other members are all similarly numbered as in the preceding Figures.

Figure 22 shows yet another embodiment of a stent comprised of cells 120 having interconnecting circumferential extending members 122. The cells have common sides or end members 124 and are arranged in groups to form bands 126 which are interconnected by joined cells 128.

While this invention may be embodied in many different forms, there are described in detail herein specific preferred embodiments of the invention. This description is an exemplification of the principles of the invention and is not intended to limit the invention to the particular embodiments illustrated.

The above Examples and disclosure are intended to be illustrative and not exhaustive. These examples and description will suggest many variations and alternatives to one of ordinary skill in this art. All these alternatives and variations are intended to be included within the scope of the attached claims. Those familiar with the art may recognize other equivalents to the specific embodiments described herein which equivalents are also intended to be encompassed by the claims attached hereto.

What is claimed is as follows:

1. A stent of generally cylindrical shape made up of a plurality of regularly arranged curvilinear bodies of same shape providing closed expansion cells, the cells
5 having relatively wide end portions joined by a relatively narrow center portion and being arranged longitudinally in rows with respect to the longitudinal axis of the stent.
2. The stent of claim 1 wherein the curvilinear bodies are also arranged in substantially parallel longitudinal rows end to end and there is included;
a plurality of longitudinal support members positioned between the
10 longitudinal rows of cells, and
a plurality of circumferentially extending connecting members substantially normal to the support members and interconnecting them to the narrow center portions of the cells.
3. The stent of claim 1 wherein the rows of cells are substantially parallel
15 and the cells are in alignment circumferentially.
4. The stent of claim 3 wherein the cells are staggered circumferentially.
5. A stent of generally cylindrical shape made up of
a plurality of curvilinear bodies providing closed expansion cells, the cells being formed of relatively wide end portions and narrow center portions and being arranged in
20 longitudinal rows around the periphery of the stent and end to end in each row;
paired longitudinal connecting members connecting the ends of adjacent cells, and
circumferentially extending members extending between cells of adjacent rows and interconnecting the cells at the narrow portions.
- 25 6. The stent of claim 5 including members which extend between adjacent cell ends interconnecting the top of one cell end to the bottom of another.
7. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies of same shape providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion and
30 being arranged longitudinally with respect to the longitudinal axis of the stent.
8. The stent of claim 7 wherein the bodies are also arranged in substantially parallel longitudinal rows end to end.

9. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion.

AMENDED CLAIMS

[received by the International Bureau on 25 March 1999 (25.03.99);
original claims 1,2 and 5 amended; original claims 7-9 replaced by new claims 7-10
remaining claims unchanged (2 pages)]

What is claimed is as follows:

1. A stent of generally cylindrical shape made up of a plurality of regularly arranged closed cell bodies providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion, the cells arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, longitudinally adjacent cells interconnected by connection members.
2. The stent of claim 1 wherein the longitudinal rows are substantially parallel, the stent further comprising
 - a plurality of longitudinal extending elongate support members, adjacent longitudinal rows of cells joined by at least one elongate support member, and
 - a plurality of circumferentially extending connecting members substantially normal to the support members and interconnecting the support members to the narrow center portions of the cells.
3. The stent of claim 1 wherein the rows of cells are substantially parallel and the cells are in alignment circumferentially.
4. The stent of claim 3 wherein the cells are staggered circumferentially.
5. A stent of generally cylindrical shape comprising of a plurality of curvilinear bodies providing closed expansion cells, the cells being formed of relatively wide end portions and relatively narrow center portions and being arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent;
 - paired longitudinally connecting members connecting the ends of adjacent cells, and
 - circumferentially extending members extending between cells of adjacent rows and interconnecting the cells at the narrow portions.
6. The stent of claim 5 including members which extend between adjacent cell ends interconnecting the top of one cell end to the bottom of another.
7. The stent of claim 1 wherein the relatively wide end dimensions are further characterized as being substantially identical to each other.
8. The stent of claim 1 wherein the cells are symmetrical in overall shape.
9. A stent of generally cylindrical shape and having a longitudinal axis and a circumference, the stent comprised of a plurality of regularly arranged interconnected curvilinear bodies individual closed expansion cells. the cells having

AMENDED SHEET (ARTICLE 19)

relatively wide end portions joined by a relatively narrow center portion, some of the cells arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, and some of the cells arranged circumferentially in circumferential rows with respect to the circumference of the stent.

10. A stent of generally cylindrical shape and having a longitudinal axis comprised of a plurality of bands which are made up of a plurality of regularly arranged interconnected curvilinear bodies of same shape providing closed expansion cells, the cells having relatively wide end portions joined by a relatively narrow center portion and being arranged end to end, longitudinally in longitudinal rows with respect to the longitudinal axis of the stent, the bands being interconnected by the curvilinear bodies shared between certain expansion cells located on adjacent edges of the bands, the certain cells being less than the number of cells which make up the band edges.

AMENDED SHEET (ARTICLE 19)

1/12

Fig. 1

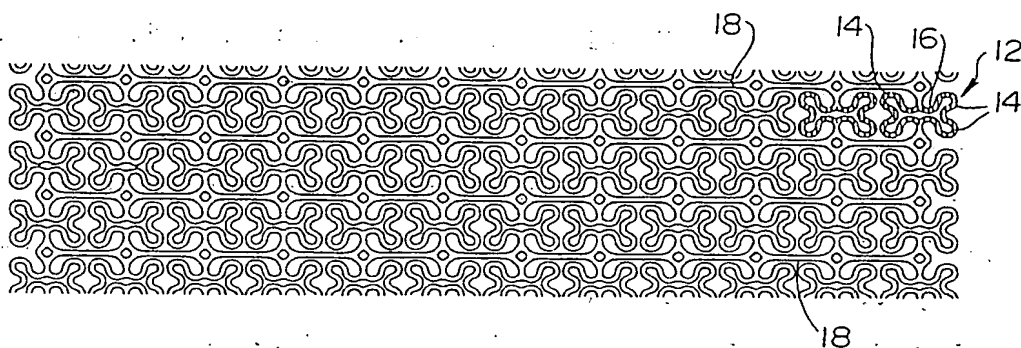


Fig. 2

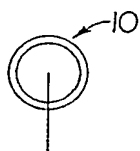


Fig. 3

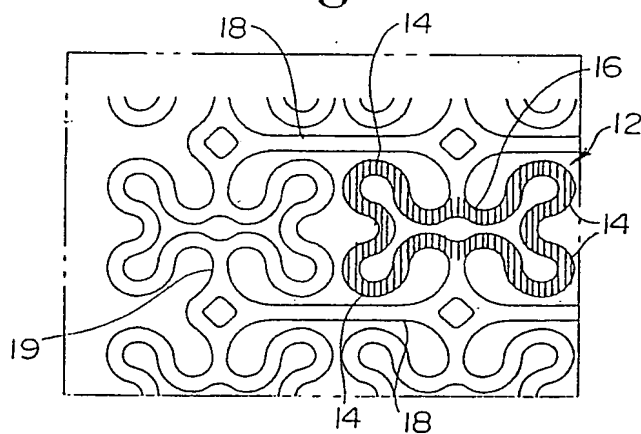
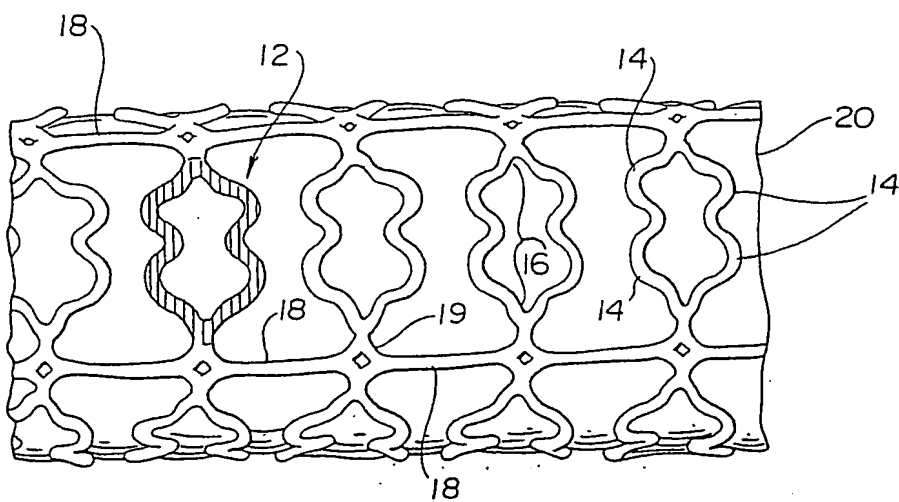


Fig. 4



SUBSTITUTE SHEET (RULE 26)

2/12

Fig. 1a

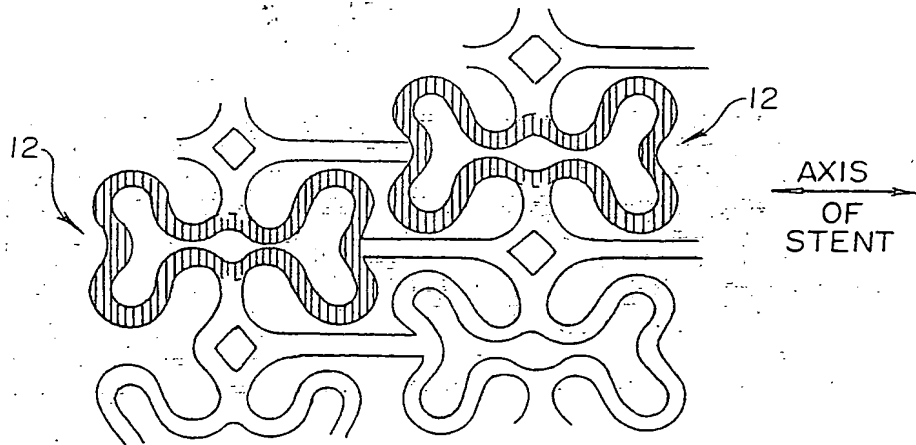


Fig. 1b

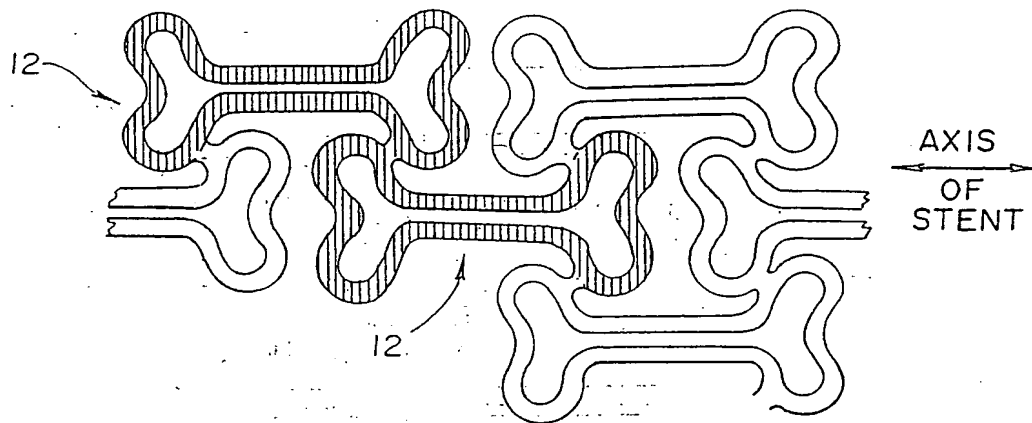
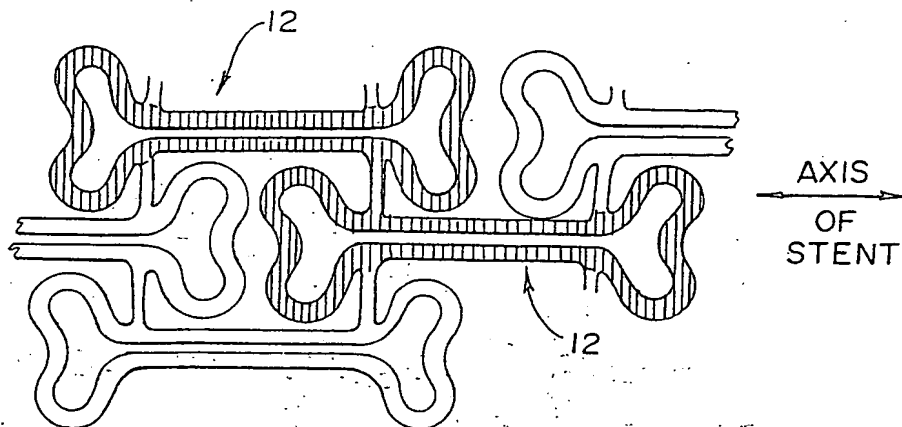
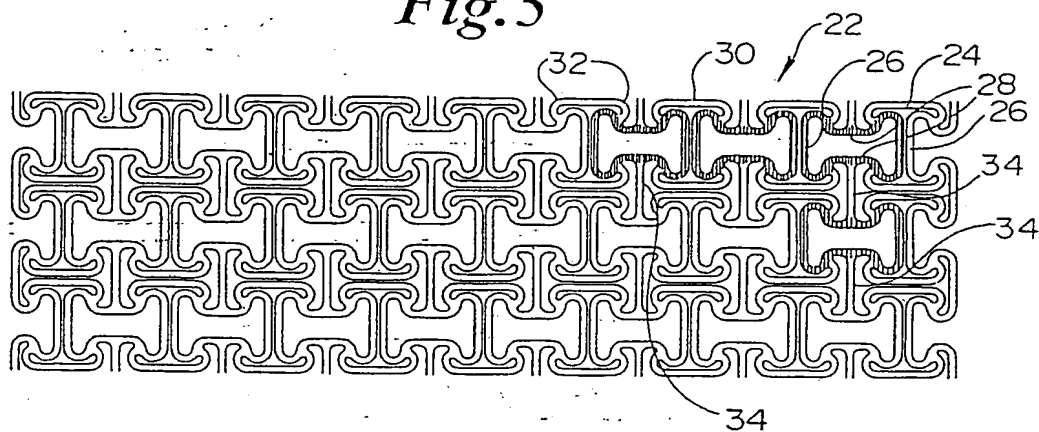
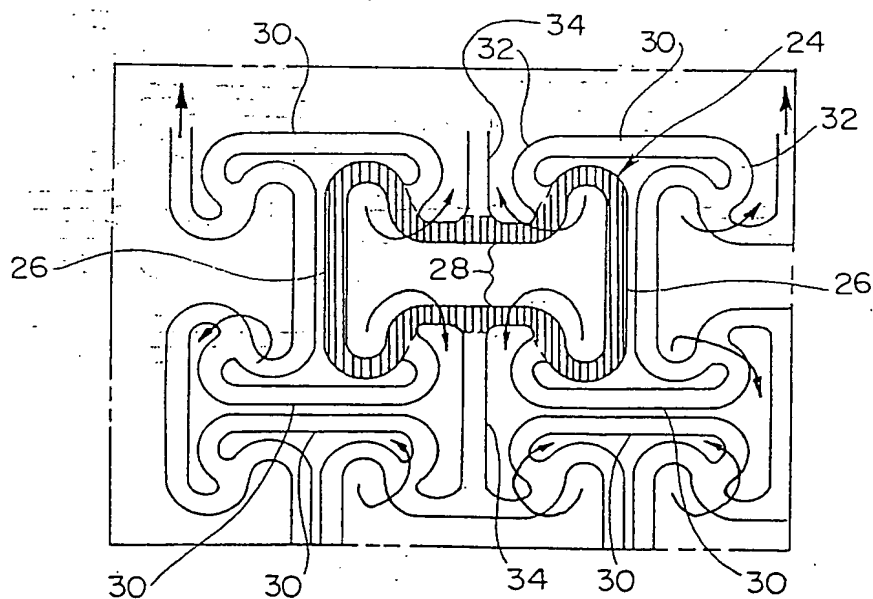
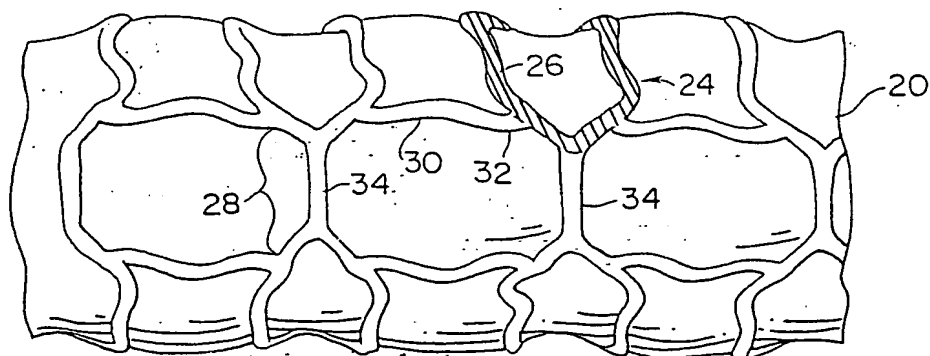


Fig. 1c



SUBSTITUTE SHEET (RULE 26)

3/12

Fig. 5*Fig. 6**Fig. 7*

4/12

Fig. 8

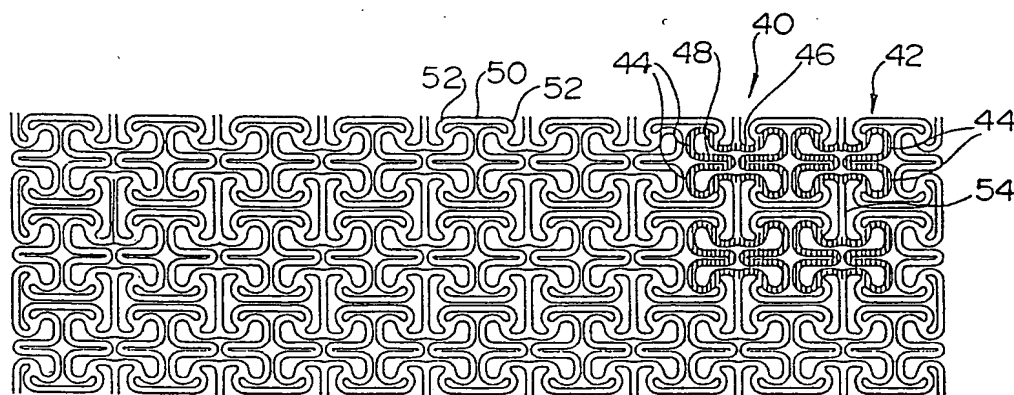


Fig. 9

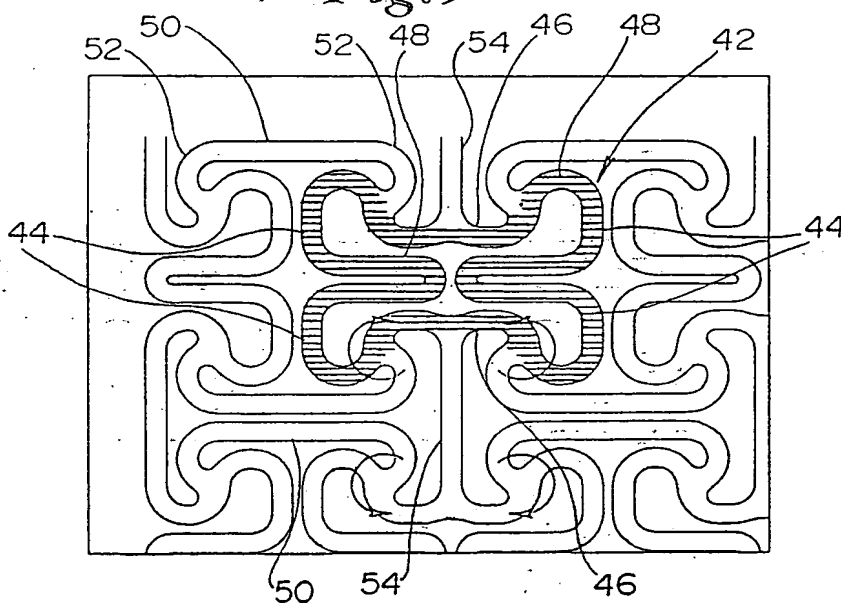
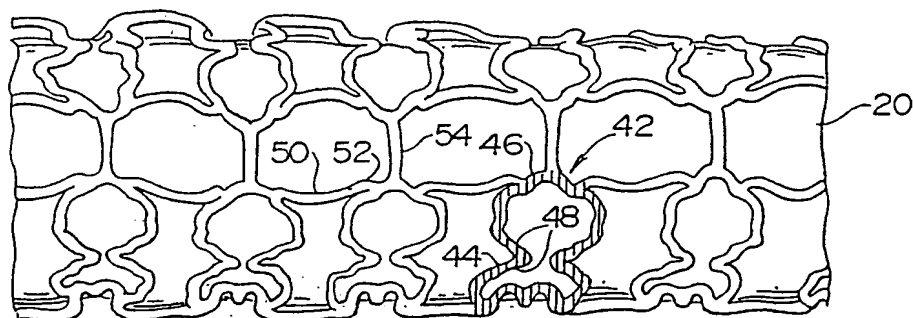
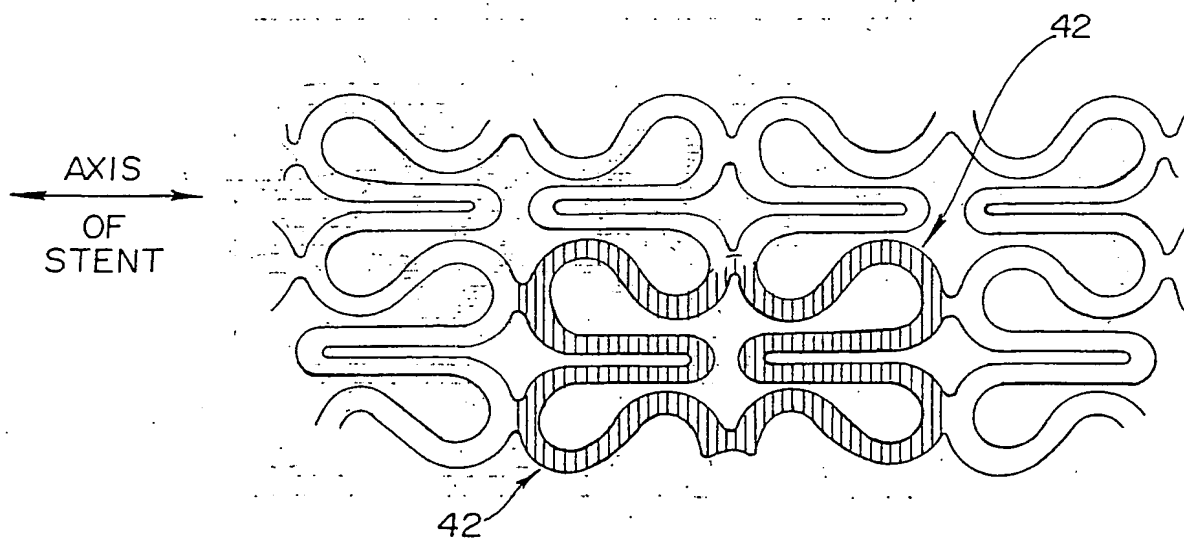


Fig. 10



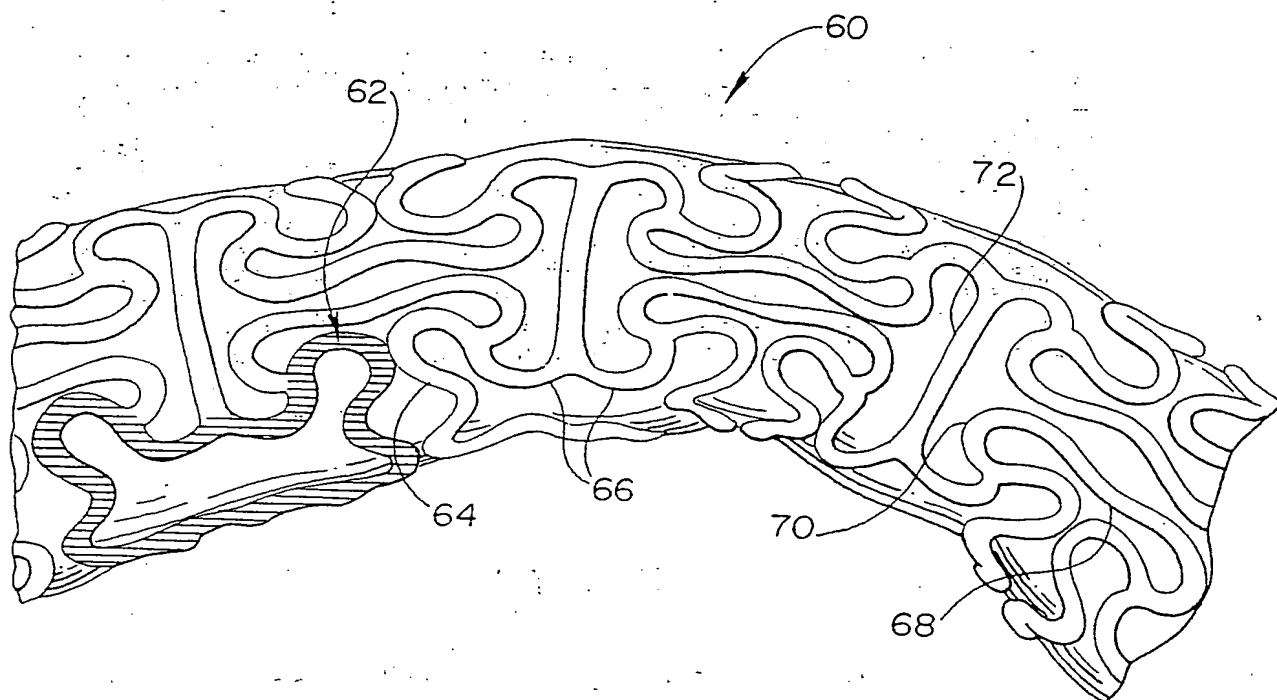
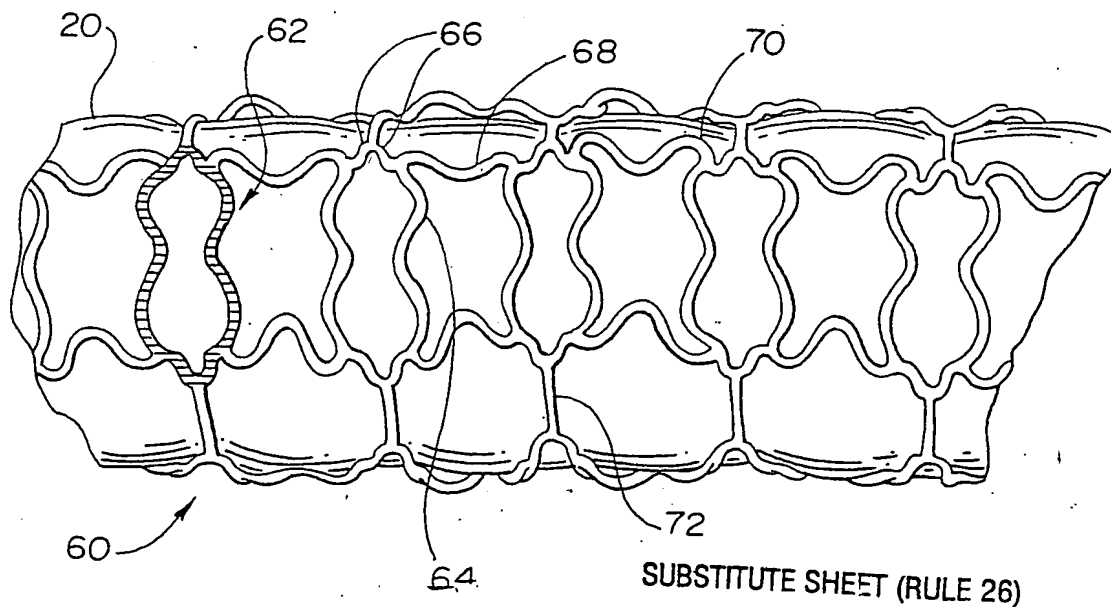
SUBSTITUTE SHEET (RULE 26)

5/12

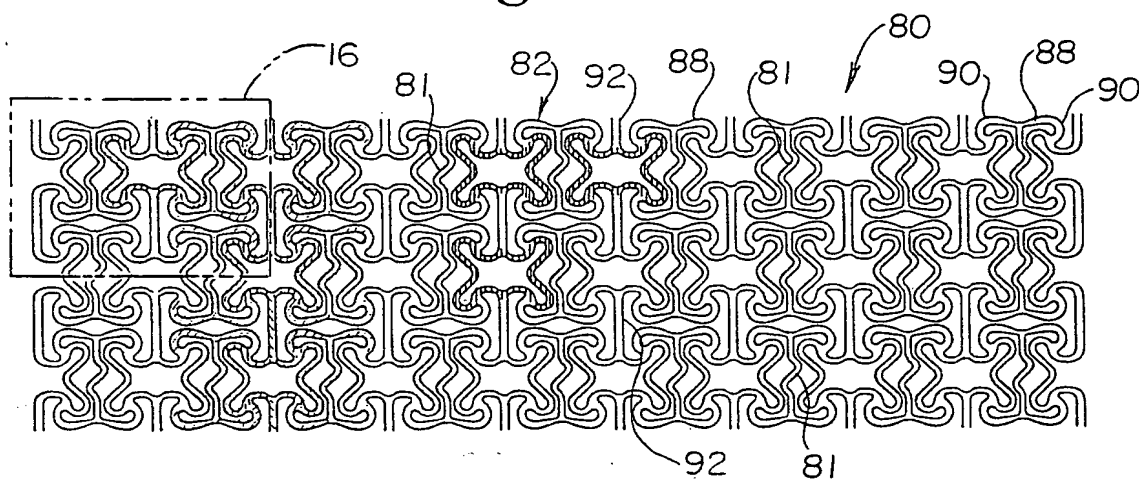
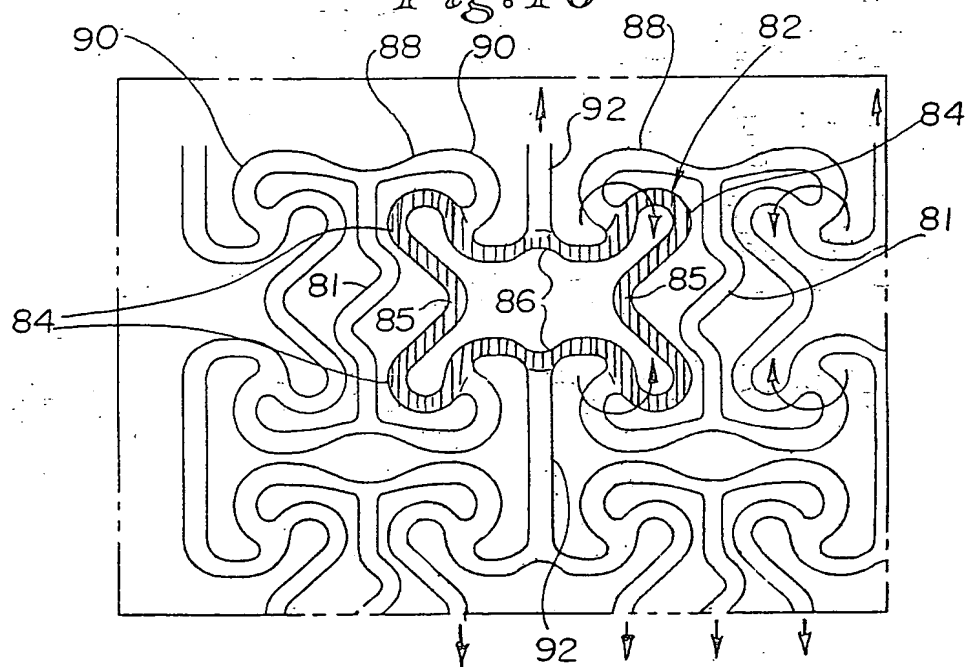
Fig. 8a

SUBSTITUTE SHEET (RULE 26)

7/12

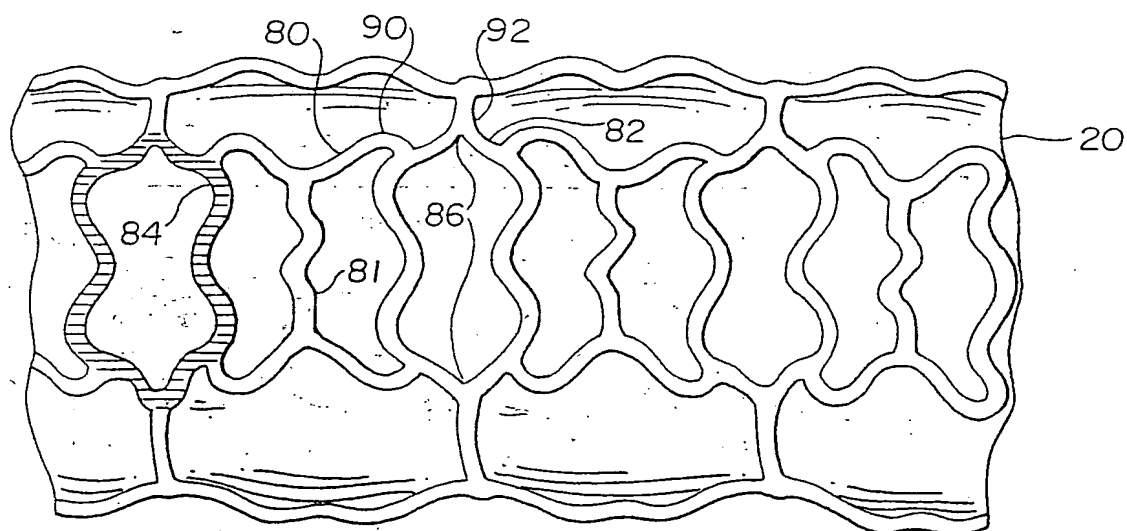
Fig. 13*Fig. 14*

8/12

Fig. 15*Fig. 16*

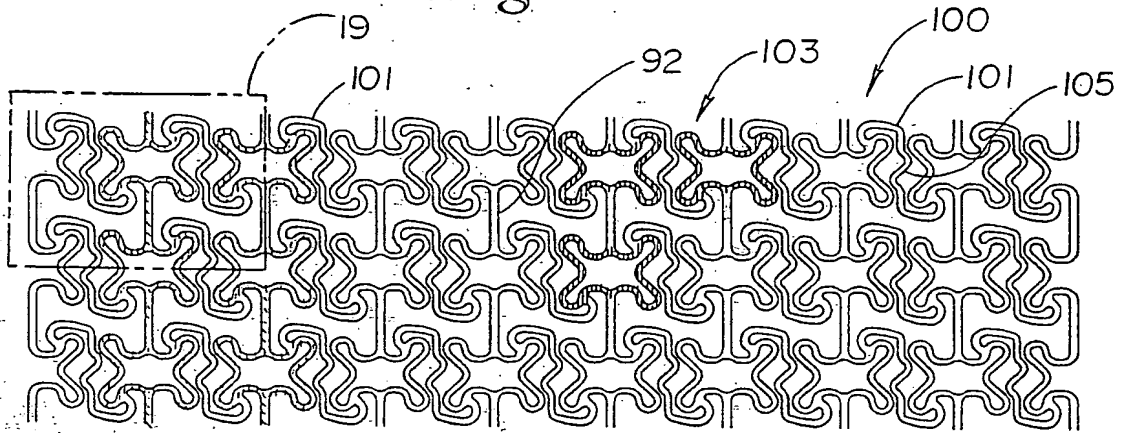
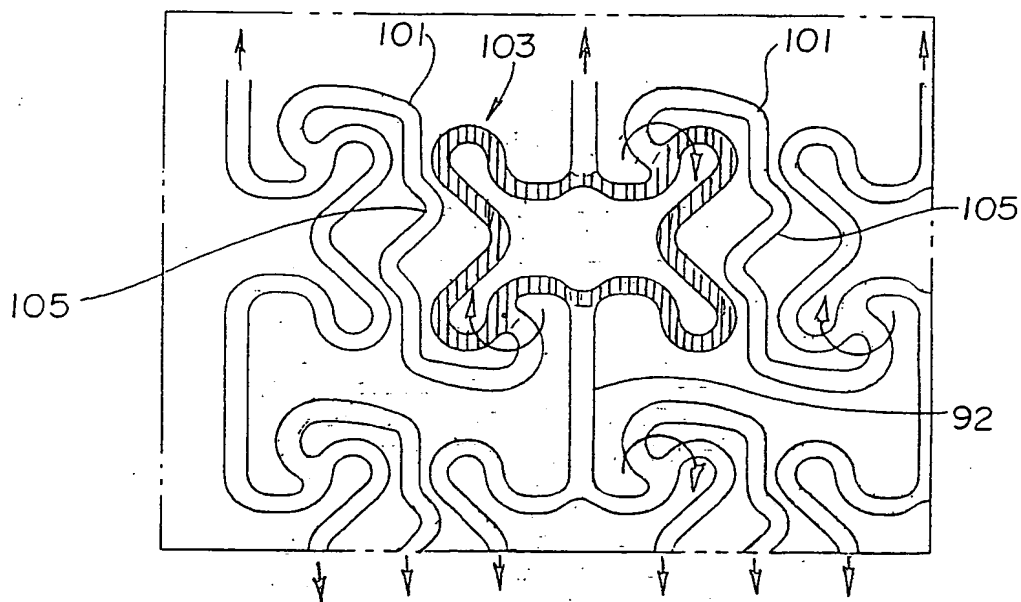
SUBSTITUTE SHEET (RULE 26)

9/12

Fig. 17

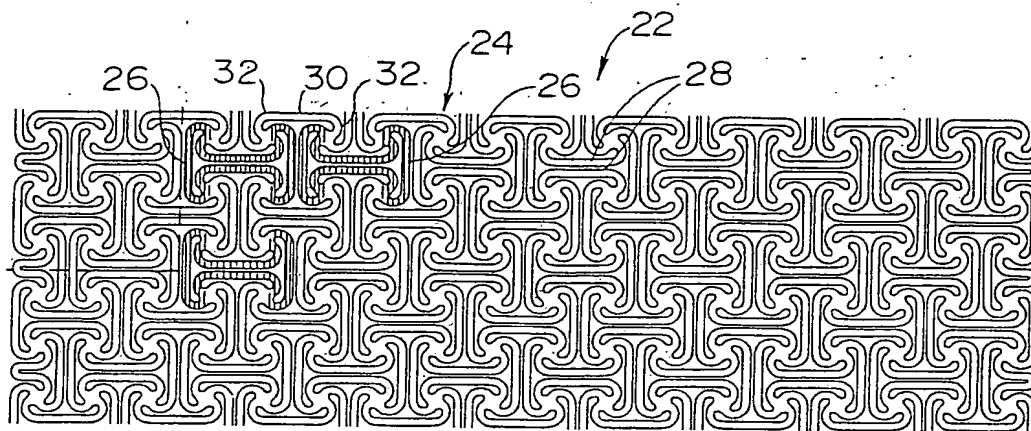
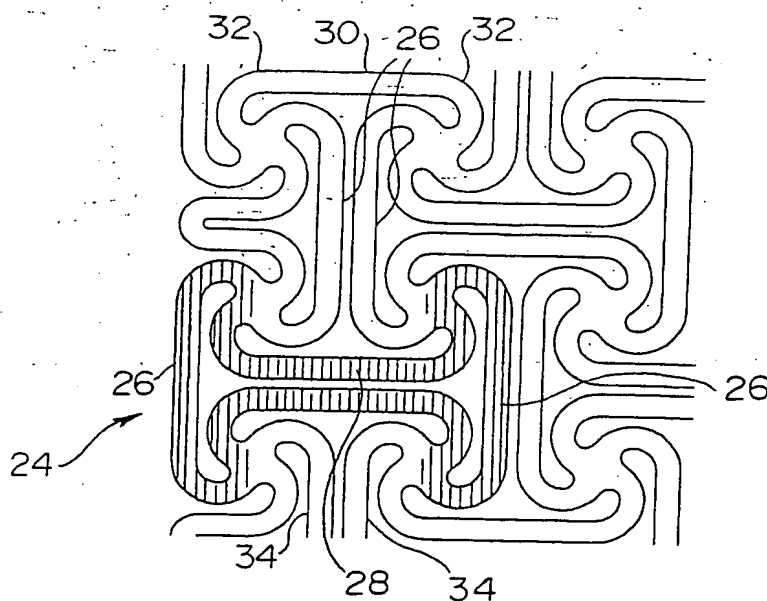
SUBSTITUTE SHEET (RULE 26)

10/12

Fig. 18*Fig. 19*

SUBSTITUTE SHEET (RULE 26)

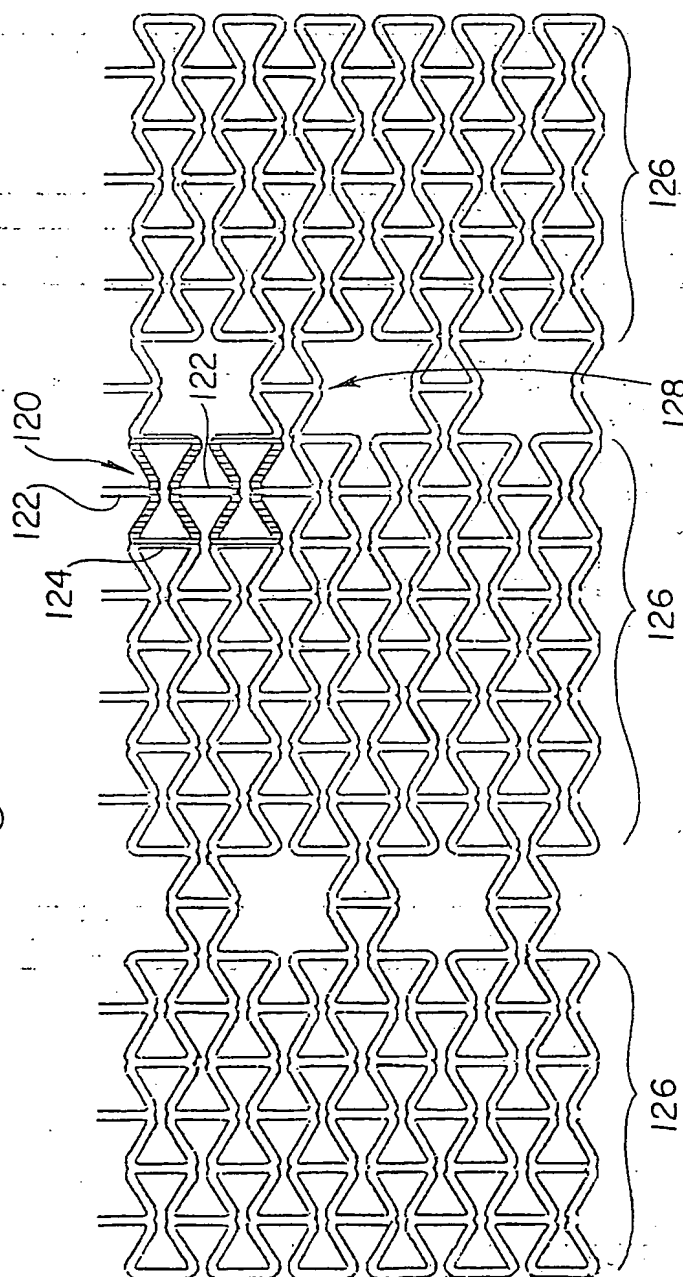
11/12

Fig. 20*Fig. 21*

SUBSTITUTE SHEET (RULE 26)

12/12

Fig. 22



SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 98/21106

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 A61F2/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5.669 932 A. (FISCHELL ET AL.) 23 September 1997 see column 4, line 64 - column 5, line 48; figure 8	1, 3, 5, 7-9
X	WO 97 33534 A (MEDTRONIC, INC.) 18 September 1997 see figure 1	1, 3, 7-9
X	WO 95 09584 A (GUERBET S.A.) 13 April 1995 see abstract; figures	7, 9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

22 January 1999

Date of mailing of the international search report

01/02/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Smith, C

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 98/21106

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5669932 A	23-09-1997	NONE	
WO 9733534 A	18-09-1997	AU 2208797 A EP 0891166 A	01-10-1997 20-01-1999
WO 9509584 A	13-04-1995	FR 2710834 A AT 162065 T AU 7858594 A CA 2173500 A DE 69407984 D DE 69407984 T EP 0722304 A ES 2115262 T JP 9503141 T	14-04-1995 15-01-1998 01-05-1995 13-04-1995 19-02-1998 03-09-1998 24-07-1996 16-06-1998 31-03-1997

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/04686

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5697971 A	16-12-1997	AU 2015497 A CA 2204586 A EP 0821921 A JP 10052503 A	29-01-1998 11-12-1997 04-02-1998 24-02-1998
WO 9603092 A	08-02-1996	US 5733303 A AT 170733 T AU 702468 B AU 3270695 A BR 9508353 A CA 2195783 A CN 1158078 A CZ 9700191 A DE 19581503 C DE 19581503 T DE 29521193 U DE 29521205 U DE 29521206 U DE 69504659 D DE 69504659 T DK 8097 A EP 0762856 A EP 0846448 A EP 0846449 A EP 0846450 A EP 0846451 A EP 0846452 A ES 2123285 T FI 970316 A GB 2304587 A,B GB 2315415 A,B JP 10503676 T LT 97022 A,B LU 90031 A NO 970289 A PL 318270 A SE 9700206 A SI 9520079 A SK 11597 A US 5843120 A	31-03-1998 15-09-1998 25-02-1999 22-02-1996 04-11-1997 08-02-1996 27-08-1997 11-06-1997 02-04-1998 16-01-1997 24-10-1996 19-09-1996 19-09-1996 15-10-1998 06-05-1999 19-02-1997 19-03-1997 10-06-1998 10-06-1998 10-06-1998 10-06-1998 10-06-1998 01-01-1999 07-03-1997 26-03-1997 04-02-1998 07-04-1998 25-11-1997 16-04-1997 26-03-1997 26-05-1997 28-02-1997 31-12-1997 08-10-1998 01-12-1998
EP 0875215 A	04-11-1998	IT T0970369 A	29-10-1998

This Page Blank (uspto)